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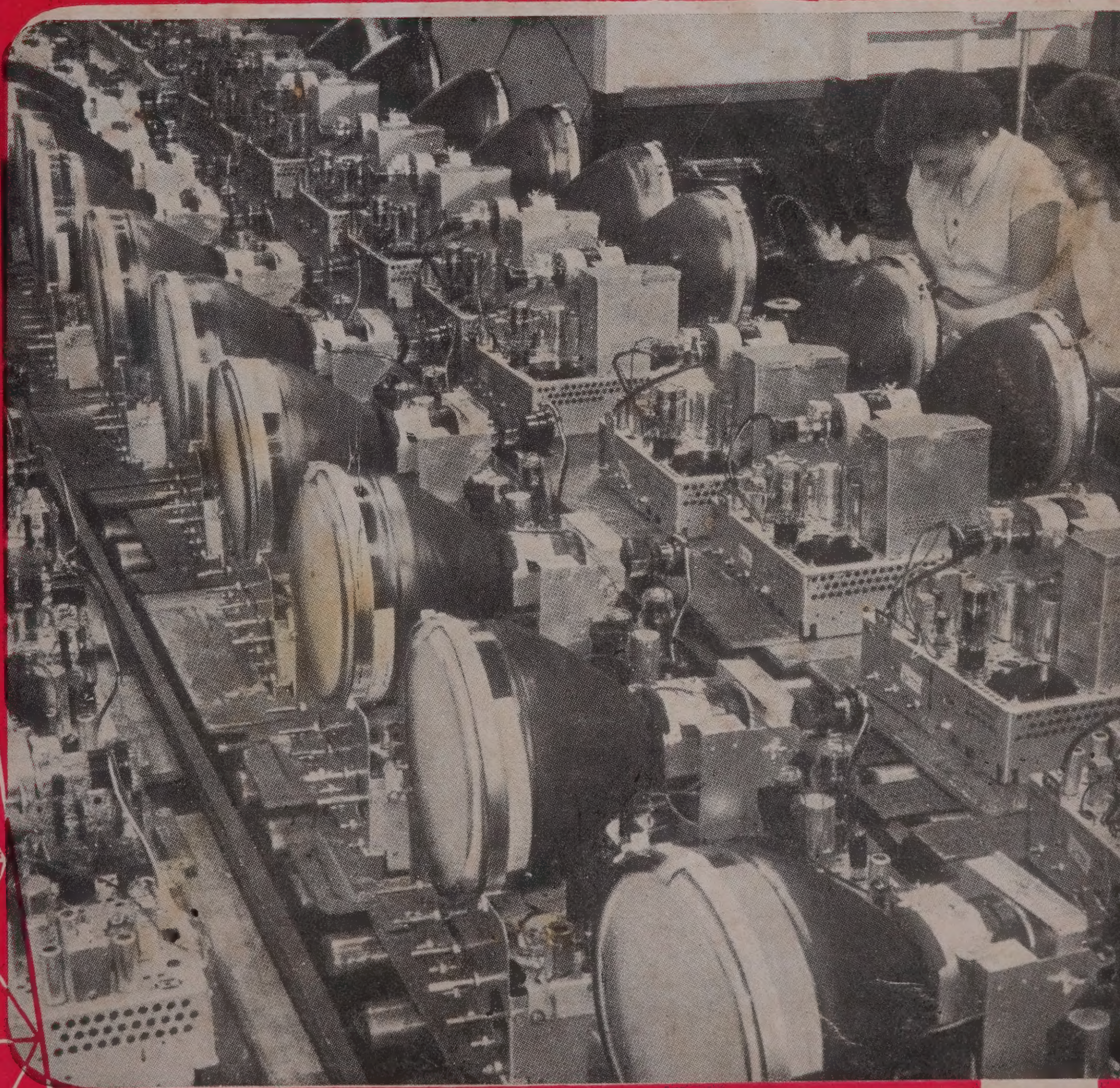

SEPTEMBER 1st, 1950 VOL. 5, NO. 7

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GUY E. MILNE

Television and the Amateur

In one of the latest issues of *Q.S.T.* to come to hand, there is an article which describes itself as a Progress Report on Amateur Television. This is a most interesting and informative document, and could well be included in that class of thing which, in the words of the classic "makes you think."

Many amateurs seem to think, and with considerable justification, too, that with full-scale television seemingly as far away as ever, it is impossible for amateur television to have any existence here, but we do not subscribe to this view. The amateur transmitter has a reputation for ingenuity in surmounting technical and economic difficulties. He also has ether space allotted for television transmission, should he like to undertake it, so that it seems a pity that the amount of activity that is going on is almost zero. Recent reports from Auckland tell of a television project which has been carried out there by radio technicians, with the financial assistance of some of the radio firms, and under the auspices of the New Zealand Electronics Institute. This was not television transmission, since the video signals generated were simply sent over a wire link for a short distance before being reproduced, but it was a praiseworthy effort to delve in a practical way into some of the mysteries of television technique that people in this country have so far been content to read about. Now this project was a fairly ambitious one, which involved importing a small camera tube from America with considerable difficulty, and several hundred pounds worth of equipment was involved. We do not suggest that this sort of thing is what amateurs, without any but their own financial resources, should necessarily attempt, but there are a number of ways in which amateurs could even now blaze a new trail across amateur radio activities, and this without the expenditure of more than many amateurs spent on an ordinary transmitter.

One of the ways in which amateur experimentation could well start would be by building a simple flying spot type of scanner. With this system a camera tube is not needed. The trick is to produce the scanning lines, or raster, on the face of a cathode ray tube of the ordinary kind. This can be easily done by using a pair of ordinary time-bases, which for initial experiments need not even be locked to any particular frequency, but even be free-running. This cathode ray tube with its scanned surface can then act as the light source. If we place a transparency in front of it, and allow the light from the tube to fall on an ordinary vacuum photocell, the light intensity is modulated by the transparency, and the amplified output of the photocell is the actual video signal, which can be transmitted over the air or along lines. In order to demonstrate the complete system on the bench, all that is needed is a second cathode ray tube, and a video-frequency amplifier following the photocell. The same pair of time-bases can be used for both tubes, thus eliminating synchronization completely, and then all that needs to be done to reproduce the picture on the face of the "receiving" tube is to apply the output of the video amplifier to the control grid.

This bench set-up could be used very effectively to demonstrate such things as the way in which the picture quality alters if the number of scanning lines, and the bandwidth of the video amplifier are changed, and with little extra complication could form the basis of a transmitter for still, and even moving pictures. For transmission, some kind of synchronization would be necessary, because it would no longer be possible to directly connect the scanning of the receiving tube with that of the transmitting one. However, for experimental work over short distances, there is little doubt that satisfactory synchronization could be effected by locking the time-base oscillators at both ends of the chain to the 50 c/sec. mains. This would eliminate the need for complicated circuits producing and transmitting synch. pulses, and for separating these from the video signal at the receiver in order to use them.

Of course, there are one or two difficulties that would have to be overcome. It may be difficult to get enough light output from an ordinary green screen cathode ray tube to give a strong enough signal output from the photocell, but there are various ways in which this might be tackled. For instance, with a high-speed trace such as would be required, an ordinary cathode ray tube would probably stand up quite well with a considerable excess of H.T. voltage, and under these conditions it would certainly give a much greater light output. The tubes with the light blue screen of high actinic value would no doubt be preferable, and it may be that some of these are available from war disposal sources. Again, it may be essential to use a photocell of the electron-multiplier type in order to get a high enough signal-to-noise ratio.

The point is, however, that if someone got down to some genuine experimentation along these lines, the whole thing might prove to be easier than it appears. At any rate, there are plenty of us these days with a liberal supply of cheap cathode ray tubes, and it would at least show that the day of amateur initiative and resource is not over if someone was to try this and other schemes that might be thought up.

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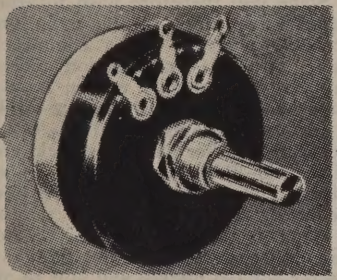

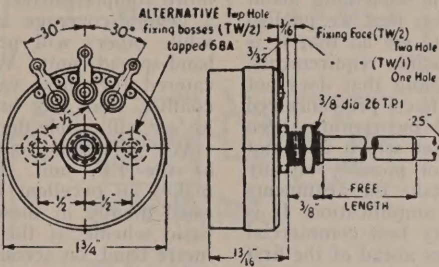

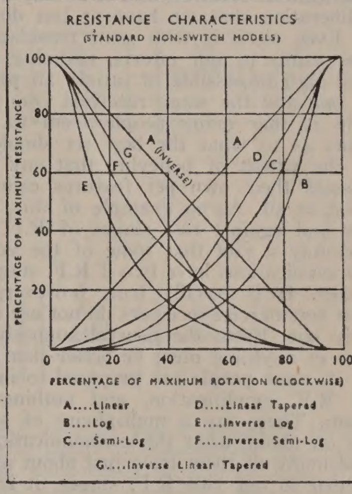

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THE "R. & E." SENIOR COMMUNICATIONS RECEIVER

This month we present the first instalment of a description of the "R. & E." Communications Receiver, whose advent was forecast in a recent Editorial. It will be found to include many novel, not to say revolutionary features, and has been designed equally for the 'phone man and the C.W. enthusiast. This instalment describes the general arrangement, per medium of the block diagram, and also gives working drawings for the chassis of the "back end." It will be remembered that the "front end" comprises the "80–40–20 Bandspread Tuner," described in these pages several months ago.

INTRODUCTION

As we have remarked before, we have repeatedly been asked by our many friends and readers to design a communications receiver, and it is only after a great deal of deliberation that we have at last done something about it. Even so, it is with some trepidation that we publish the results of our efforts, realizing as we do that it is well-nigh impossible to satisfy all possible requirements, in one and the same receiver. One thing that does not help is that many people seem to have pre-conceived ideas as to what the best set should incorporate—even to the extent of believing that any set which does not possess their own pet features cannot possibly be any good at all. As an example of this, take the arguments for and against two stages of R.F. amplification. It is certainly a fact that some of the very best commercial communications have two T.R.F. stages ahead of the first mixer. It is equally true, however, that some of the best commercial receivers do not use two stages, but have only one. From the general supposition that a set with two of anything must be better than a set with only one of it, some people are prepared to insist that two stages of R.F. amplification, and nothing else, will do for them. There are a multiplicity of such arguments that go on about what the communications set should have, and many of them have just about as much validity! To return to our two R.F. stages, it is certainly true that these have certain advantages over a single stage when they are properly constructed and aligned, but it is equally true that compared with the extreme difficulty of seeing that they *are* properly constructed and aligned, the advantages can be reckoned to be comparatively slight. And, what is more important, when a frequency is reached at which the two R.F. stages show up to their best advantage, one can obtain better all-round performance in any case by constructing a converter to precede the main receiver. In other words, it is exceedingly doubtful whether, if one is not a manufacturer, with considerable technical resources not possessed by anyone else, it is at all worth-while hankering after two R.F. stages.

Now we do not intend to argue at length the pros and cons of all the design features which we may or may not have included, because it is certain that we have left out some things that people would have liked included, just as we must have included things which a good many would have just as well have done without, but we have made one major decision that will affect everyone, and which, we think, will enable the design generally to suit a good many more than it otherwise might have done. We refer to the building of the receiver in two parts, a "front end" or signal section, and a "back end" or I.F. section.

By so doing, we are tackling the problem in a logical manner, for to a very large extent, the design of the set following the first oscillator-mixer valve decides whether it is really suitable as a communications receiver. In the same way, such a division enables many of the inevitable clashes of opinion to be resolved in different ways, according to the wishes of the builder, but without in any way affecting the design or operation of the "back end." For instance, some intending builders will not be satisfied with the 80–40–20m. coverage of the bandspread tuner already described, and will want something more comprehensive. Some will therefore wish to attach a general-coverage short-wave tuner to the main unit, while others will probably want to use a commercial band-spread unit. With two-unit construction already catered for, these varying requirements will in no way conflict, since any tuner which ends with output on 455 kc/sec will enable the I.F. unit to be used.

We will thus concentrate rather on the "back end" of the I.F. unit. The "80–40–20 Bandspread Tuner" makes an excellent front end for those who are interested mainly in these bands. It is unfortunate that the basic scheme of the tuner is not adaptable to the ten-metre band, on account of its great width, but those who habitually use a converter for ten metres will still be able to use it as long as its I.F. lies within one of the lower bands. For those who are doubtful about how to cope with the ten-metre band, but who like the idea of the bandspread tuner for the lower bands, we would recommend that a good 10-metre converter with an I.F. at, say 4 mc/sec., would give an excellent solution to the problem of all-band coverage.

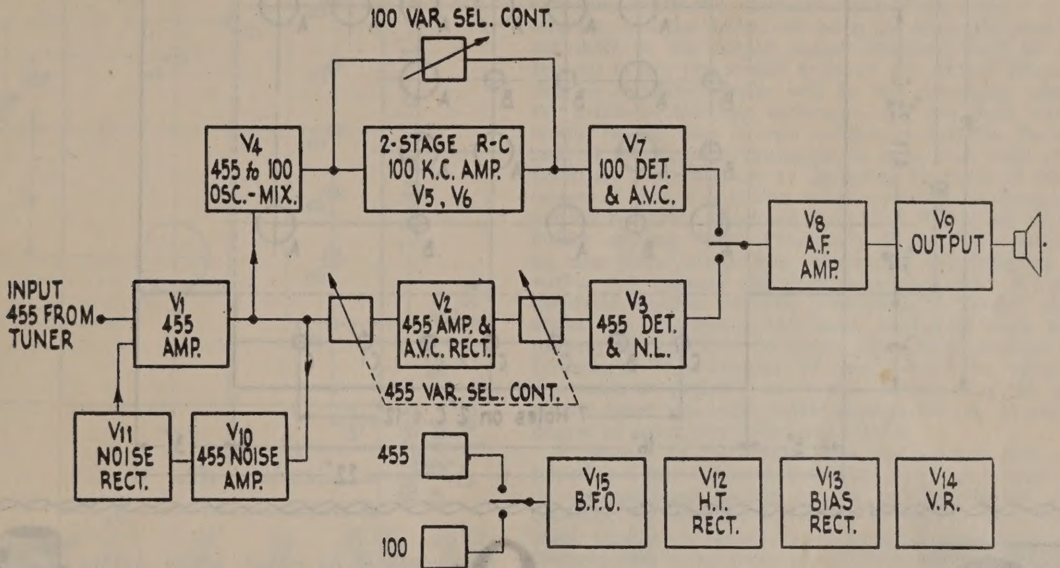
LINE-UP OF THE I.F. UNIT

Fig. 1 gives a block diagram of the I.F. unit. This contains everything for the complete receiver, with the sole exception of the tuner, and as somebody will no doubt feel impelled to remark, just as well, seeing that it includes fifteen valves! As might be expected, not all of them are in use at any one instant, since the unit really contains two separate I.F. channels. The idea of this is that by having two completely separate channels, one for 'phone, and the other for C.W., most of the conflicting requirements of these two types of reception can be resolved, and thus satisfied separately. It thus becomes possible to cater as efficiently as possible for both types of reception, without in any way reducing the performance of one at the expense of the other. There is, however, some little carry-over between the functions of the two channels, since the 455 kc/sec channel can be used for C.W. reception, if desired, and since under certain circumstances it may be desirable to use the 100 kc/sec channel for 'phone reception.

The I.F. chosen for the speech channel was 455 kc/sec., because this forms an excellent compromise between selectivity, for rejecting adjacent channels, and a reasonably wide pass band for receiving the sidebands of 'phone transmission. In addition, it saves a great deal of trouble if the input frequency of the unit is 455 kc/sec, since so many commercial tuning units and coil kits are designed for this frequency, or something very near it. Accordingly, the first valve, V_1, is the first 455 kc/sec. amplifier.

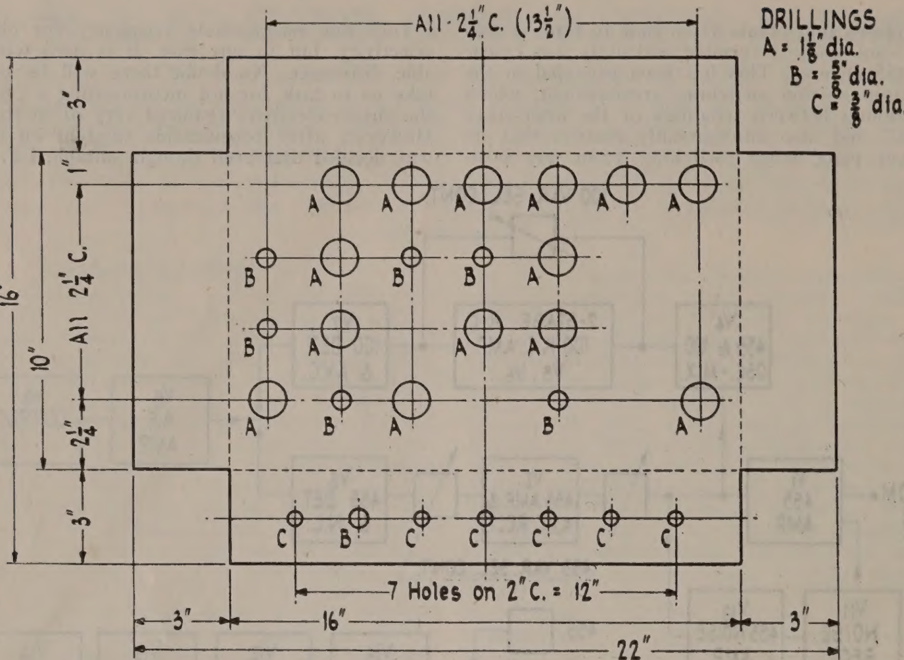
In order to realize a satisfactory degree of adjacent-channel selectivity for 'phone reception, it was decided to use two stages of 455 kc/sec. I.F. Further, in order to provide the best possible quality on 'phone consistent

with the conditions that obtain from time to time, it was thought that some kind of variable selectivity was essential for the 455 channel. This has been provided in the form of a three-position switching arrangement, which varies the coupling between windings of the inter-stage "transformers," and also automatically ensures that no de-tuning takes place when switching from any position to any other. The "transformers" referred to are actually separately shielded single tuned circuits, each pair being coupled together by means of an ingenious arrangement of condensers, controlled by a wave-change type of switch, operated from the front panel. In order to improve the run of the leads carrying high I.F. voltages, V_2 has been made a duo-diode-pentode, with the diode acting as A.V.C. rectifier. This arrangement also allows one diode of the double diode V_3 to act as a clipper type of noise limiter, the other being the detector for the 455 kc/sec. channel. V_8 and V_9 form the common audio channel, fed alternatively from the 455 or 100 kc/sec. detector at the turn of the switch, which is also brought out to the front panel. This switch also selects the two entirely separate A.V.C. outputs, and at the same time selects the B.F.O. frequency, for whichever channel is in use.



A most important feature of the 455 kc/sec. channel is the Lamb noise suppressor, comprising V_1, V_{10}, and V_{11}. Rather it is a modified Lamb system, as we shall see when we come to describe the circuitry in detail. Nevertheless, it is very effective indeed, and whatever criticisms may have been levelled at the Lamb noise suppressor from time to time, this modification of it certainly does not warrant any of them. To our observation, it is the most effective thing in noise suppressors we have yet come across, and is very well worth the slight extra expense that it adds to the receiver. In one locality, where the electrical interference was particularly troublesome, it was noted that the suppressor was so effective that it enabled a weak signal to be heard that was not otherwise audible at all! And although we say it ourselves, there are not many noise-reducing circuits which will do that!

After the first 455 kc/sec. I.F. amplifier there branches off an oscillator-mixer valve, converting the signal to 100 kc/sec. This is the now well-known scheme of using a very low intermediate frequency for obtaining extra selectivity, but in our case, it is used with a considerable difference. No doubt there will be some who will take us to task for not incorporating a crystal filter for the super-selectivity required very often for C.W. work. However, after considerable thought on the matter, it was decided that even though suitable I.F. transformers may be available, and crystals, too, it would be preferable from a number of points of view to omit the crystal filter, and obtain the same effect by other means. Most of all, it was thought that the system ultimately decided upon would give greater return for time and effort spent than would a crystal filter. For one thing, the circuit used here gives continuously variable selectivity. In the least selective position, we have a selectivity which is the same as that of any normal I.F. stage using two 100 kc/sec. transformers. In the most selective position of the control, the circuit all but "rings," indicating that any further increase in selectivity would be unprofitable. In the original, the selectivity on the "broad" position of the 100 kc/sec. control was such that speech was just readable and no more. In the "narrow" position, it was so selective that speech was quite unreadable, the pass band being only a few hundred cycles. Now for C.W. reception, this is the sort of selectivity that is wanted, and to have such selectivity, moreover, continuously variable by means of a front panel control, is something in the way of an operating feature that no crystal filter will provide. Unfortunately, there is one feature of the crystal filter that this circuit will not give, and that is the rejection "notch" which can be used to give exceptional attenuation at one particular frequency near to the desired signal. However, if this is really wanted, it can be done by means of audio selectivity, and on the whole, the arrangement is much more easily used than a crystal filter. How many owners of crystal filters are there who have no idea how to use them? The same thing can hardly apply to the present scheme, since it is so simple to use. The method of obtaining the exceptional selectivity from a single 100 kc/sec. stage is one that we think has not before been applied to receivers, though it has found use as a highly selective amplifier for wave analysers, again in plase of a crystal filter. It will be found described in principle by Terman in his *Radio*



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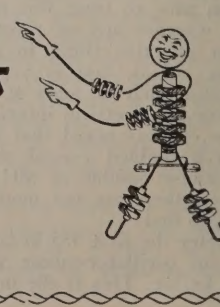

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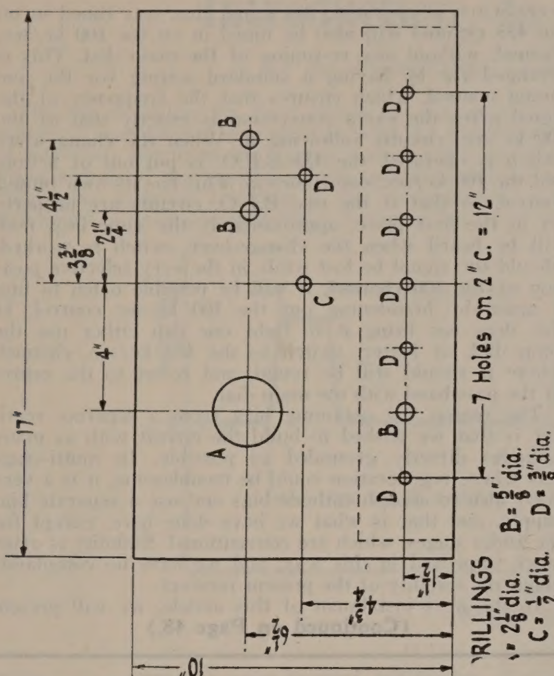


Engineers" Handbook, in the chapter on Measurements.

Briefly, the scheme is to take a two-stage resistance-capacity coupled amplifier. Input is applied through a tuned circuit connected at the first grid in the ordinary way. Then a high degree of negative feedback is applied from the plate of the second stage to the cathode of the first. This considerably reduces the gain of the two stages, but it is restored to its original figure by means of positive feedback applied between the output plate and the input grid. The positive feedback is made just sufficient to cancel the negative feedback. Now the circuit is so arranged that the negative feedback is independent of frequency, but the positive fedeback is maximum only at the resonant frequency of the input circuit, and falls off very rapidly indeed away from resonance. This leaves a net negative feedback at frequencies away from resonance, and this increasing attenuation is added to that already due to the response curve of the tuned circuit. By making the plate load resistor of the second valve of this special amplifier a potentiometer, and taking both feedbacks from the moving arm, the additional selectivity can be controlled from zero to maximum at a turn of the potentiometer. One great virtue of the arrangement is that no de-tuning effect is discernible, and that if the tuning is carefully done in the *broad* position, the signal will still be there after turning the control to maximum selectivity. This could certainly not be done if the increase of selectivity were accompanied by any change in the resonant frequency.

The great advantage of this arrangement over a crystal filter is that it takes little or no skill to operate, and yet gives selectivity that is comparable, for C.W. reception. In designing the receiver for C.W., consideration was given to the fact that when very high selectivity is used, extra good stability must be built into any oscillators that may be used. It was therefore necessary to undertake stability tests on the 80–40–20 Bandspread Tuner in order to ascertain whether or not the circuits in it were stable enough to use with a very selective back end. One of the incidental advantages of the system of bandspread used in the tuner is that on the two high-frequency bands, where stability is most important, the tuner is itself a double superhet, with two oscillators. Now one of these works on the high side of the signal frequency, while the other works on the low side, so that any drifts that the two oscillators may possess tend to cancel out. For example, should the oscillators drift by the same amount (and the drifts will be in the same direction) the net drift in the output signal frequency will be zero. In any event, the actual drift of the output frequency due to oscillator drifts will be the difference between the drifts of the two oscillators, and not their sum, as would be the case if both oscillators were on the same side of the signal frequencies. In tests that were undertaken as a preliminary to designing the rest of the receiver, it was found that when switched on from cold, neither oscillator produced more than 1000 c/sec. of drift before settling down. Practically all of this was found to take place within five minutes of switching on, and within ten minutes the drift was negligible. When an oscillator reaches its final frequency, it "hunts" slowly about this frequency, and these oscillators were found to vary by less than 50 c/sec. about their average final frequency. This amount of drift would be quite undetectable in practice, so it was decided that the bandspread tuner was quite stable enough for any practicable degree of selectivity to be used after it.

A feature of the circuit that has not yet been mentioned is a fine tuning control that has been incorporated in the oscillator section of the oscillator-mixer which converts the 455 kc/sec signal to 100 kc/sec. A very small trimmer is placed across the oscillator circuit and is brought out to the front panel. This acts as a fine trimmer that can be used quite easily when the set is in its most selective condition. Its use will be to trim out a very close interfering signal, or to take up drift occurring during the initial warm-up period. It can also be used to tune from one signal to another within the pass-band of the 455 kc/sec. channel. This is another reason for having a fairly broad position on the selectivity of the 455 chain. When the 100 kc/sec. is in use, there will be no need at all for selectivity in the 455 channel, and this can usefully be broadened somewhat, to allow a small band of frequencies to be explored by the oscillator of the 455-100 converter stage. This oscillator, incidentally, operates on 355 kc/sec. Special coils for this frequency are available commercially, as are, in fact, all coils and transformers used in this receiver, except for those in the tuner, which are easily made by hand anyway.

THE 455 TO 100 CHANGE-OVER SWITCH

When we wish to change from the 455 channel to the 100 kc/sec. one, it is necessary not only to switch the detector outputs, but also the A.V.C. lines, and the B.F.O. coils. All this is incorporated in the one switch, which is a wafer type with three two-position switches on the one wafer.

Some readers will no doubt remark that they do not want A.V.C. when they are listening to C.W., but we would strongly recommend them to try it. The reason for this preference is often that few, if any commercial or amateur sets arrange for a suitable type of A.V.C. to be available for use when on C.W. For example, a set which uses a crystal filter and has A.V.C. for phone use rarely allows the A.V.C. to be used when on C.W. Many sets even switch off the A.V.C. automatically when the B.F.O. is brought into use. It is true, of course, that the same sort of A.V.C. cannot be used for receiving the two kinds of transmission, but making the ordinary A.V.C. system suitable for C.W. is very simple, and

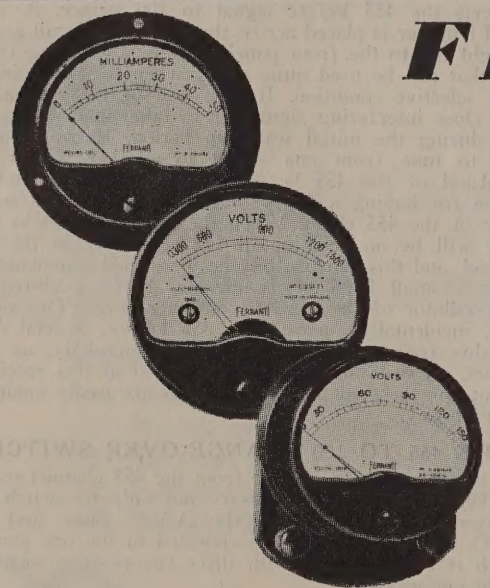
consists only in switching in an extra-large A.V.C. filter condenser, which give a very long time-constant to the A.V.C. The practical effect of this is that the average level of the dots and dashes controls the amplification of the set, and that in the spaces between words or even sentences, the A.V.C. bias does not disappear because the very large condenser does not have time to discharge. As a result, the set does not "breathe," or rapidly change its sensitivity between the characters of the signal, which is most annoying, and happens when a conventional A.V.C. system is used on C.W. Of course, due to the long time-constant, this sort of A.V.C. has no time to respond to rapid fading, but that is hardly its purpose. The advantage of the A.V.C. in C.W. reception is that one is not perpetually altering the R.F. or I.F. gain of the set so as to give the same audio output on a variety of signals as one tunes through the band. The A.V.C. is able to hold the audio beat note almost at constant level, thus making the adjustment of the B.F.O. much easier in the first place, and giving almost the same type of signal in the output, irrespective of the strength of the input signal.

In tuning in a C.W. signal, it is intended that searching of the band should be done using the 455 kc/sec. channel, so that this has been provided with a B.F.O. coil, with its own separate adjustment. Under good reception conditions it will not be necessary to use the 100 kc/sec. channel at all, but this may have to be done at any time, owing to the possible onset of interference. The alignment of the set is such that when the change-over switch is operated, the signal that was tuned in on the 455 channel will also be tuned in on the 100 kc/sec. channel, without any re-tuning of the main dial. This is arranged for by having a standard setting for the fine tuning control, which ensures that the frequency of the signal after the extra conversion is exactly that of the 100 kc/sec. circuits following it. When the change-over switch is operated, the 455 B.F.O. is put out of action, and the 100 kc/sec. one comes in. This has its own tuning control, so that if the two B.F.O. circuits are properly set in the first place, approximately the same beat note will be heard when the change-over switch is worked. Should the signal be lost while in the very selective position of the 100 channel, it will be possible often to find it again by broadening out the 100 kc/sec control. If this does not bring it to light one can either use the main dial, or better, switch to the 455 kc/sec. channel, where it should still be found, and re-set to the centre of the pass band with the main dial.

The reason for obtaining bias from a separate rectifier is that we wished to build the circuit with as many cathodes directly grounded as possible. In multi-stage sets where regeneration could be troublesome, it is a very good idea to abolish cathode bias and use a separate bias supply, and that is what we have done here, except for the audio stages, which are conventional. Stability is often much improved in this way, and we have no complaints about the stability of the present receiver.

In the next instalment of this article, we will present

(Cootinued on Page 48.)



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Introduction to Pulse Modulation

By the Engineering Department, Aerovox Corporation

The use of *pulses*, or short bursts of radio-frequency energy, is well known in connection with the transmission of television synchronizing signals and in radar practice. Pulse signals of this type have been applied to microwave radio-relay systems, resulting in the revolutionary new techniques of voice communication known as "pulse modulation." Cross-country, point-to-point radio-relay circuits utilizing these techniques have many practical advantages and are rapidly replacing older types of wire, cable, and relay-link equipment in both commercial and military applications.

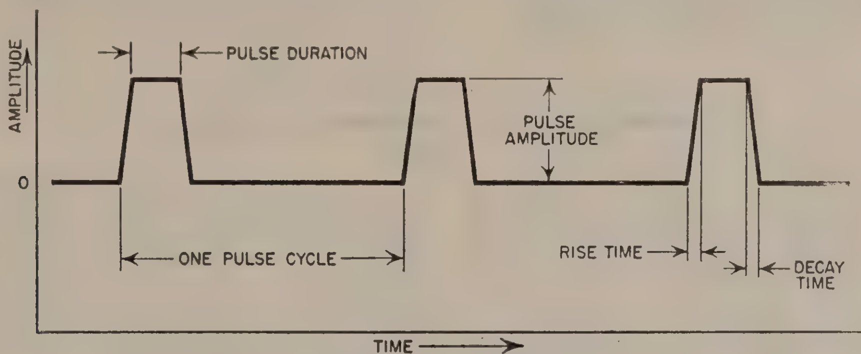
The advantages of pulse modulation include economy of equipment size and weight, good speech quality, adaptability to multiplex operation with low inter-channel cross-talk, enhanced signal-to-noise ratios, and ideal utilization of the special micro-wave tubes such as magnetron and klystron. Microwave frequencies are used in most radio-relay systems employing pulse modulation since relatively wide bandwidths are required, and because the shorter wavelengths permit the greater antenna directivity required to maintain privacy in point-to-point radio telephony.

There are four general kinds of pulse modulation:
Pulse Amplitude Modulation (PAM);
Pulse Time Modulation (PTM);
Pulse Code Modulation (PCM);
Composite Pulse Modulation (CPM).

In addition to these basic types, there are over forty methods of pulse modulation using combinations of the above types impressed as pulsed subcarriers on either amplitude modulation or frequency modulated R.F. carriers. Since most of these systems are highly complex, and in some cases quite impractical, the purpose of this article will be more aptly served by confining this discussion to the more basic types of pulse modulation.

PULSE FUNDAMENTALS

A *pulse* may be defined as a single electrical disturbance of short duration. As used in radar, television, and communications, pulses usually have rectangular or trapezoidal wave-forms. Such wave-forms represent the abrupt rise of a D.C. voltage from zero to a constant value, the maintenance of that value for a short period of time, and an abrupt decrease to zero again. A recurrent series of such pulses, and the standard terms used to define pulse characteristics, are shown in Fig. 1. The frequency of occurrence of the pulses is called the *pulse repetition frequency* and is commonly abbreviated PRF.



PULSE CHARACTERISTICS
FIG.1

The duration of the pulses employed in pulse modulation is usually measured in *microseconds*. The product of the pulse duration in seconds and the pulse repetition rate in pulses-per-second is called the "duty factor" or "duty cycle." It represents the ratio of the time that a pulse is present to the time of one complete pulse cycle. As an example, if the pulse duration is one microsecond (.000001 second) and the PRF is 10,000 p.p.s., the duty cycle is .01, or 1/100th. This means that the pulse occupies only 1/100th of the period of one pulse cycle. In other words, there are 99 microseconds between each one-microsecond pulse.

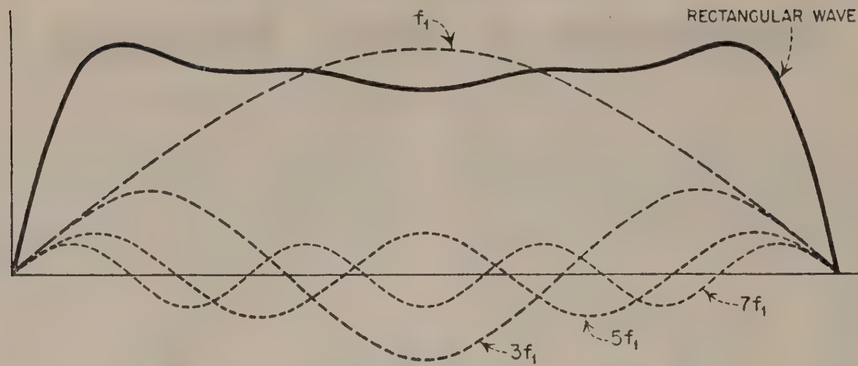
Although the pulse repetition frequencies employed in pulse modulation are usually less than 100 kilocycles, frequency components much higher than this are required to form essentially rectangular pulses. In other words, if the pulse is broken down into its sine wave components, it is found to consist of a *Fourier series* made up of a *f*undamental and its odd harmonics, as depicted in Fig. 2. The steepness of the sides of the pulse determines the number of harmonic frequencies required to form it. Theoretically, if the pulse were perfectly rectangular, it would contain an infinite number of sine wave harmonic components. Under these conditions, an infinitely wide band of frequencies would be required to transmit it without distortion. In practice, frequencies up to several megacycles are usually present, necessitating the use of video frequency circuits for the handling of pulses. The actual video bandwidth required depends on the rise or decay time of the pulse in accordance with the approximate relationship:

(1)
$$F = \frac{1}{2t_r} \text{ megacycles}$$

Where:
F is the required video bandwidth.
t_r is the pulse rise or decay time, whichever is shorter. (Microseconds.)

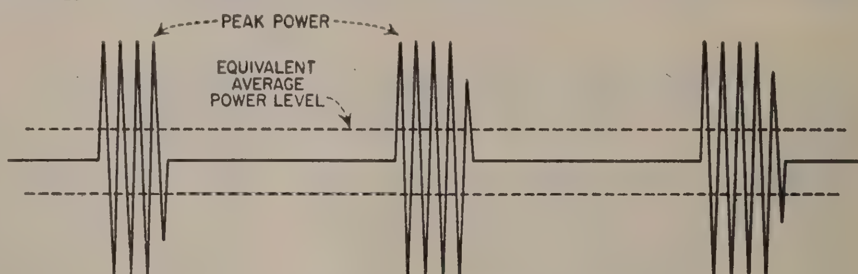
Thus, a pulse having a rise time of .2 microseconds would require a video bandwidth of 2.5 megacycles for undistorted transmission.

When pulses of this type are used to modulate an



FORMATION OF PULSE BY FOURIER COMPONENTS
FIG. 2

R.F. carrier, the result is a train of R.F. pulses like those of Fig. 3, having wave envelopes essentially like those of the modulating video pulses. The R.F. bandwidth required to faithfully transmit the pulses is twice as large as the video bandwidth given in Eq. 1, however, since an amplitude modulated carrier has side-bands on either side which are removed in frequency by the amount of the highest frequency components present. The distribution of transmitted energy within this bandwidth would be approximately as shown in Fig. 4, which is the R.F. *spectrum* of a typical pulsed carrier. For extremely short pulses having very fast rise times, the R.F. bandwidth may be many megacycles. For this reason, pulse modulated systems usually require considerably greater bandwidths than is needed for other communication systems having equal rates of intelligence transmission.*



PULSE-MODULATED R.F. CARRIER
FIG. 3

When a transmitter is pulse modulated, it is possible to obtain instantaneous R.F. power outputs which are very high compared to the continuous wave power obtainable from the same transmitter. These high "peak" powers are achieved because it is possible to apply very high voltages to the transmitting tubes and to allow them to draw very high anode currents during the short pulses without exceeding the *average* power dissipation ratings of the tubes. Thus, tubes rated for a few watts *average* power output when operated c.w. may be capable of delivering kilowatts of instantaneous or *peak* power when pulsed. The average power contained in a pulse train is related to the peak power by the duty cycle, in the following manner:

(2)

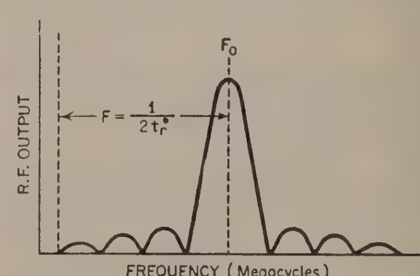
Average Power (P_{ave}) = Peak Power × Pulse Duration × PRF
= Peak Power × Duty Cycle.

In the R.F. pulse train of Fig. 3, the average power level is shown by the dotted lines. It represents the power level which would be present if the pulse peaks were smoothed out to form a continuous signal containing equal average energy.

*This is why amateur pulse communication is allowable only on V.H.F. bands above the 420-460 mc/sec. band.—Editor.

MODULATION SYSTEMS

Most of the simple systems of pulse communication function by causing the average power of the pulse train to vary in accordance with the modulating signal. As shown by Eq. 2, this may be accomplished by varying either the peak power, the pulse duration, or the pulse repetition frequency. These systems are classified as pulse *amplitude* modulation (PAM), pulse *duration* modulation (PDM), and pulse *frequency* modulation



SPECTRUM OF PULSED TRANSMITTER
FIG. 4

(PFM), respectively. Figure 5 illustrates how pulse sequences of these three types would appear when modulated by a sine-wave signal. The dotted lines represent the average power variations of the pulse train. This is the wave which is reproduced in the receiver when the pulse carrier is demodulated.

The process whereby the characteristics of the pulse train are modulated by the instantaneous value of the

modulating signal is known as "sampling." In other words, the modulating wave is sampled at intervals determined by the PRF. To reproduce the modulating wave without appreciable distortion, the sampling frequency must be 2.5 or 3 times higher than the highest modulating frequency. Thus, to effectively reproduce voice frequencies up to 3000 c.p.s., a sampling PRF of about 9000 p.p.s. would be required.

Another form of pulse modulation which has been used to some extent is called *pulse position modulation*, abbreviated PPM. In this system, the transmitter pulse duration and amplitude are held constant, and the average repetition rate and average power nearly so. Modulation is accomplished by varying the time interval between successive pairs of pulses. These varying intervals are then converted to pulse duration modulation at the receiver by a "flip-flop" multivibrator. The first pulse of each pair triggers the multivibrator to start a locally generated pulse, which continues until the second pulse arrives to turn the circuit off.

TIME-DIVISION MULTIPLEXING

Multiplexing is the technique of impressing two or more communication channels on a single circuit, so that each can be operated simultaneously without interference with the others. This may be done by separating the individual channels on either a frequency or a time basis. Pulse modulation is particularly adaptable to a

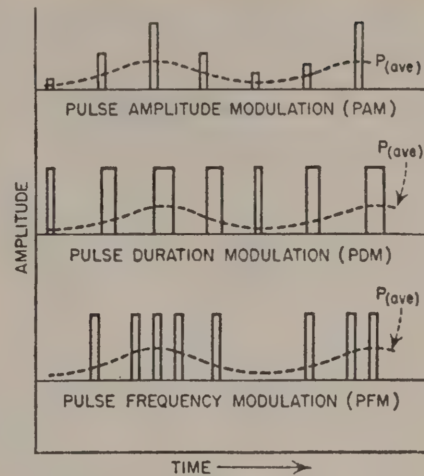


FIG.5

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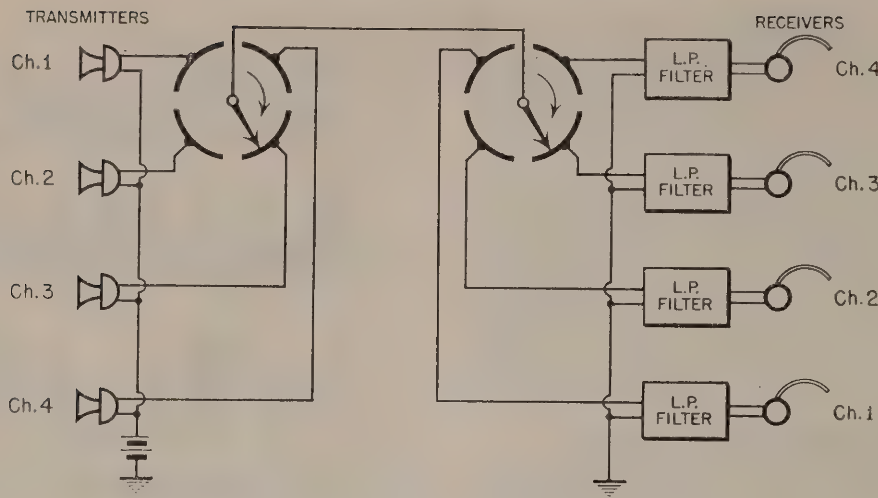


ILLUSTRATING TIME-DIVISION PULSE MULTIPLEXING

FIG. 6

time-division multiplexing because of the long intervals between pulses during which no signal is being transmitted. This makes it possible to send other pulse signals during these intervals which may be separated at the receiver by their time of occurrence.

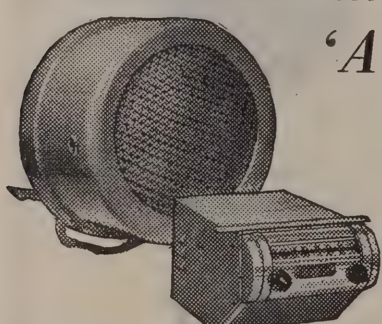
The basic principle of time-division multiplexing is illustrated in the hypothetical telephone circuit of Fig. 6. Here four pairs of telephone transmitters and receivers are connected to corresponding segments of a pair of commutators which have brushes or "wipers" rotating in speed and phase synchronism. A single telephone line circuit connects the brushes so that correspondingly numbered transmitters and receivers are connected together in rapid sequence. If the commutation frequency, or sampling rate, is several times as high as the highest voice frequency used, the speech output of each microphone will appear at the matching receiver. A low pass filter is used in each receiver circuit to separate the speech frequencies from the sampling frequency.

In this system of multiplexing, each voice channel uses the wire circuit for a short period of each commutation cycle. Thus, the time of each cycle is divided among the four channels—hence the term *time-division* multiplex. It will be apparent that this principle will work equally well if the wire circuit is replaced by a radio circuit.

In practical systems of time-division multiplexing, commutation is accomplished electronically, rather than mechanically. A synchronizing pulse, which is distinguishable from the channel pulses because it is of longer duration, is sent out by the transmitter before each sampling cycle to actuate timing circuits at the receiver. These timing circuits disable the input circuits of all receiver channels except the one which should receive a pulse at that time. Thus, the receiver "commutator" is automatically synchronized with the transmitter. As many as eight voice channels may be conveniently multiplexed on a single radio frequency circuit by this method.

Systems of pulse modulation which make use of pulses of constant amplitude have signal-to-noise ratios comparable to FM systems. This is because noise modula-

(Continued on page 48.)



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An anti-fading broadcast antenna; the service area of a broadcast transmitter within which interference between ground and skywave components does not occur can be extended by reduction of high-angle radiation from the antenna. The sectional mast is the answer.

—*Electronics* (U.S.A.), May, 1950, p. 82.

AUDIO EQUIPMENT AND DESIGN

Very widely divergent views are held on the subject of amplifier output impedance in relation to the reproduction of transients. An experimental investigation is described.

—*Wireless World* (Eng.), May, 1950, p. 166.

The proper reproduction of F.M. programme material demands an integrated high-fidelity system, and to control unruly speakers the output stage must deliver its power from such a low impedance as to short-cut wayward excursions of the cone. The cathode follower system described has this characteristic.

—*Wireless World* (U.S.A.), June, 1950, p. 49.

CIRCUITS AND CIRCUIT ELEMENTS

Efforts are sometimes necessary to design selective circuits without inductance and containing only resistance and capacity for use at low frequencies. The elements of such circuits are given.

—*Wireless World* (Eng.), June, 1950, p. 223.

ELECTRONIC DEVICES

A description is given of induction heating equipment for the production of starter gear rings for motors.

—*Electronic Engineering* (Eng.), June, 1950, p. 236.

Area computing apparatus is briefly described, its chief use being the estimation of the area of pieces of leather.

—*Ibid*, p. 83.

Automatic exposure control for aerial cameras is effected by photoelectric servo controls of lens aperature, and the same instrument is applicable to motion-picture and television cameras.

—*Electronics* (U.S.A.), May, 1950, p. 74.

MATERIALS AND SUBSIDIARY TECHNIQUES

The study of luminescent materials has been advanced by X-ray analysis to evaluate the different characteristics of inorganic phospers.

—*G.E.G. Journal* (Eng.), April, 1950, p. 89.

Here is a simple treatise on the screening of electrical components which goes back to simple principles and is invaluable for all who have a screening problem in mind.

—*Wireless World* (Eng.), June, 1950, p. 211.

Modern soft-soldering technique; present-day methods of obtaining speed and reliability are described with the theory of operations.

—*Wireless World* (Eng.), June, 1950, p. 218.

New applications for crystal diodes; here are described several interesting and handy gadgets which use the germanium diodes.

—*Radio and Television News* (U.S.A.), June, 1950, p. 64.

Plastic embedded circuits. The process consists of preparing a mould, setting the circuit components in the mould; pouring in the prepared resin and polymerizing into a rigid solid.

—*Electronics* (U.S.A.), June, 1950, p. 66.

MATHEMATICS

Phase angle measurements are comparatively easy to make on the oscilloscope. The method of making the calculations and correcting various types of errors is described.

Electronic Engineering (Eng.), June, 1950, p. 238.

MICROWAVE TECHNIQUES

Microwave lenses, Part III. This article deals with the profiles, tolerances and bandwidth of various types of lenses.

—*Electrical Engineering* (Eng.), June, 1950, p. 227.

MEASUREMENTS AND TEST GEAR

Scientific research sometimes requires the measurement of a very small amount of physical movement and meters for such are criticized and described. Some uses of the instrument are the accurate measurement of thickness, for sensitive weighing apparatus, torque and tensile forces.

—*Electrical Engineering* (Eng), June, 1950, p. 215.

Crystal controlled oscillators have now been developed to a degree where it is possible to obtain very fine tolerance that can be checked in terms of the earth's rotation. A method is described which enables any frequency to be produced that is harmonically related to a sub-multiple of a standard frequency.

—*Ibid*, p. 220.

The determination of gas temperatures in modern boilers and high-temperature furnaces raises many problems and a new supersonic technique has been developed.

—*Wireless World* (Eng.), June, 1950, p. 89.

An audio oscillator in conjunction with an oscilloscope may be used to identify non-linearity, harmonic distortion, phase shift, and frequency response variations in an audio system. The oscilloscope figures are given.

—*Radio and Television News* (U.S.A.), June, 1950, p. 66.

An impedance bridge for less than ten dollars. A high frequency buzzer provides the A.C. A list of components and full description is given.

—*QST* (U.S.A.), June, 1950, p. 19.

TRANSMISSION

Earlier pulse systems have been extravagant in bandwidth, and a narrow band system is described. Gating circuits for time allocation cost less than complex filtering. A local oscillatory circuit at the receiver can compensate for distortion caused by restricted bandwidth.

—*Wireless World* (Eng.), June, 1950, p. 202.

TELEVISION

Television monitoring is described, the instrument being a specially designed high-class receiver capable of detecting any small faults in the picture.

—*Wireless World* (Eng.), June, 1950, p. 206.

Television camera tubes; the image orthicon which operates under conditions of very low intensity of light is described. The tube incorporates electron multipliers in the amplification system.

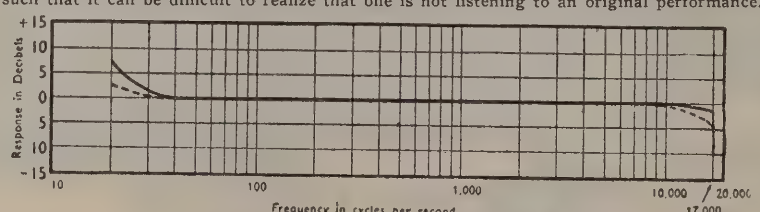
—*Wireless World* (Eng.), May, 1950, p. 162.

Deflector coil characteristics. In this article, the third of the series, the particular requirements of frame coils are described.

—*Wireless World* (Eng.), May,, 1950, p. 176.

BRIERLEY PICK-UPS

The JB/P/R Pick-up has been designed with the sole object of obtaining as realistic reproduction from gramophone records as possible with negligible wear of records. The real test is a listening test and not specification data, and, provided the recording and the rest of the equipment are of a sufficiently high standard, the results obtained are such that it can be difficult to realize that one is not listening to an original performance.



Dotted Line refers to Ribbon Pick-up Full Line refers to Armature Pick-up
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Low-frequency Resonance: 5 c/s. (approximate).
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Provision is made for vertical motion of the point to minimize so far as possible defects due to the "pinch" effect. The Pick-up is quite robust, and there is no possibility of damage occurring from normal use; accidental dropping on to the record surface will not cause any damage.

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WRITE FOR PAMPHLETS

An earlier article discussed the advantages of "spot wobble" for the elimination of "lininess" on the raster. The subject is here discussed in greater detail.

—*Wireless World* (Eng.), May, 1950, p. 189.

R.C.A.'s new tri-colour kinescope; the principles of the three gun tube with the circuitry is given.

—*Radio and Television News* (U.S.A.), June, 1950, p. 47.

Television optics is discussed in detail with special attention to projection apparatus.

—Philips' Electrical Application Bulletin (Holland), April, 1950, p. 64.

The Schmidt System of projection explained in detail with the optical principles involved.

—*Ibid*, May, 1950, p. 95.

Simplified television units for industry comprise a special "vidicon" tube and employ sync. systems which can be monitored by an ordinary TV receiver.

—*Electronics* (U.S.A.), June, 1950, p. 70.

MISCELLANEOUS

Memories of Marconi. Some interesting biographical notes by Marquis Solari, one of Marconi's earlier associates.

—*Wireless World* (Eng.), June, 1950, p. 81.

In considering the elementary principles of electrostatics, an apparent paradox arises in the case of the electrostatic voltmeter. The explanation involves an overhaul of misconceived ideas derived from electroscopes and pith-balls.

—*Wireless World* (Eng), May, 1950, p. 183.

The future of electronic clerical machines and the requirements of industry are discussed. As no two clerical jobs are quite alike the difficulties are more for the industrial engineer than for the electrician. The possible systems for reducing clerical work are outlined.

—*Electronics* (U.S.A.), May, 1950, p. 69.

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TRADE WINDS

Winding Wires—Australian Manufacture

The Rola Company (Aust.) Pty. Limited, announce the appointing of the Swan Electric Company Limited, P.O. Box 90, Wellington, the sole New Zealand agents and distributors for Rola winding wire. The Swan Electric Company Limited will shortly be carrying a full range of wires ex stock sale and are now acting as indent agents for shipments direct from Rola Company (Aust.) Pty. Limited to New Zealand buyers.

The Rola Company is the only major manufacturer of enamelled winding wire in Australia; the industry was established at the factory of the Rola Company of Melbourne approximately ten years ago, and during this time has become by far the major supplier of winding wire to the Australian electrical, radio, and communication industries. The company commenced as a very small unit, but the output of the factory rapidly increased until today it is one of the major organizations in the electrical industry.

During the war and the immediate post-war period, the Rola Company had the full responsibility of keeping the vast Australian electrical industry (which is the third industry in Australia) supplied with this vital commodity. In doing this the company gained an enormous amount of experience which reflects itself in the product which is available to Australian and New Zealand users today.

Export restrictions from Australia made it impossible for Rola Company to ship more than token exports to New Zealand in the past. That position has now been rectified and it is understood that export licences from Australia and import licences to New Zealand are both fairly readily available. Under these circumstances Rola Company will be able to supply to the Swan Electric Company sufficient of its wide range of wires to enable that company to take care of the requirements of New Zealand buyers.

All Rola Company's wires are enamelled, the company not being manufacturers of wires that are not first enamelled. Additionally they can supply single and double cotton enamelled wire, single and double silk and artificial silk enamelled wire, single paper enamelled wire, double tough enamelled wire (synthetic).

The development of tough enamelled wire in Australia has been a major development. For some time the electrical industry has been seeking a wire which would provide the tough qualities of cotton enamelled wire without unduly increasing the space factor. Synthetic enamelled wire was the answer and this class of wire rapidly became popular.

To investigate synthetic enamels fully, the Rola Company sent overseas their chief engineer and charged him with the responsibility of bringing back to Australia information which would enable them to manufacture synthetic enamelled wire second to none in the world. This was done and Rola is now manufacturing this wire they know has an advantage, namely, it is available in two classe "A" and "B", "A" being the general purpose wire for armatures, etc., "B" being the wire which is recommended for use with sealed unit refrigeration, and in other locations where under contact from extremely harsh solvents such as methanol.

Another factor of Rola wire is its spooling. It is well known in the electrical industry that good spooling is an essential of good wire. Here again Rola sent an expert overseas to collect information on the subject, the result is that their spooling is incomparably superior to that normally associated with winding wire. The types of spools used are such that their return to the factory is essential. This relieves the buyer of the necessity of purchasing a spool which is of no further use.

It is expected that the Swan Electric Company will find a ready market for these Australian products. Stocks will be available in Auckland, Chistchurch, and Dunedin.

* * *

Tentative data on a new Radiotron germanium crystal rectifier (type GEX44) has been received. It is very similar to type 1N34 which it will replace in most applications. Expectations are that it will be available at a low retail price, making this a very popular item with manufacturers and amateurs.

* * *

Rola Company (Australia) Pty. Ltd. has been registered in New Zealand as a foreign company purely for administrative purposes, and as Swan Electric Company Ltd. are acting as their sole agents, no business will be entered into direct with any New Zealand firm other than, or through Swan Electric Company.

* * *

S.T.C. developments at Lukes Lane, Wellington recently showed the need to enlarge their factory space. To solve this problem the office staff has been removed to premises lately vacated by Russell Import Co., at 57 Dixon Street. Here are to be found J. H. Prickell, manager, Dave Browne, commercial manager, Jack Wilson, sales manager, Keith Kennedy, accountant.

* * *

Six low-powered transmitters have been ordered by the British Broadcasting Corporation for the Television Service, from Marconi's Wireless Telegraph Co. Ltd. They are three 5 kw. vision and three 2 kw. sound transmitters, one of each forming a complete low-power television station.

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A Medium or High-powered Class C Amplifier for the Six-metre Band

WITH the increasing interest among amateur transmitters in the higher frequency bands, higher output powers for use under difficult conditions, or for attempts at DX working, are becoming desirable even on the six-metre band. This article describes a fool-proof method of making a 50-watt tube "perk" on this band with even less difficulty than is usually encountered. An unusual, but highly efficient neutralizing system is used.

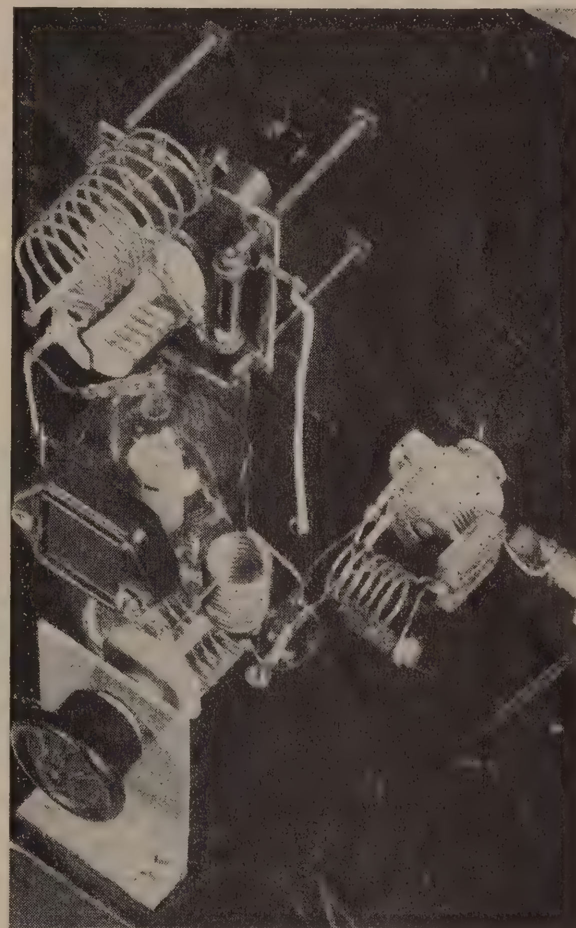
INTRODUCTION

These days of crowded bands, more and more amateurs are turning towards the U.H.F. and V.H.F. bands for their comparative freedom from Q.R.M. and for their own particular fascination, which, though difficult to define, is none the less real. No longer can it be said, however, that working the bands above 30 mc/sec. is pioneering, but even so, the number of men who are willing to tackle the U.H.F. and V.H.F. bands is still limited by the comparative lack of practical information about how to get the best results in this unfamiliar territory. These days, six metres itself can hardly be reckoned V.H.F., when amateurs are working successfully on 420 mc/sec. and even higher, but this does not alter the fact that "ordinary" gear such as is commonplace below 30 mc/sec. just does not work so well up here, and in some cases does not work at all. The object of this article is, therefore, to show how a very tractable medium or high-powered final can be built for six metres, and that as long as a few quite simple precautions are taken, the difficulties often associated with driving a large tube, and getting efficient operation from it, can be made to disappear completely.

WHAT IS DIFFICULT ABOUT "SIX"?

To those in the know, of course the answer is a contemptuous "Nothing!" But we are ordinary chaps, and we have not found it easy to get the same performance from our transmitters on ten metres as we get on 80. How much more difficult, we think, must the 50–54 mc/sec. band be! We want to know why those difficulties are there, just what they are, and how they can be circumvented, so that the expert's answer doesn't help us much. Let us examine the problem for ourselves, then, and see if there is not a ray of daylight. What are the incipient difficulties that have started to rear their heads on 10, and which we expect to be rampant on six? First and foremost there is the choice of a tube or tubes. We are after, say, anything over 20 watts output, so that we can immediately rule out anything in the nature of an over-worked receiving tube. In any case, few of us these days, except for low power at low frequencies, still cling to valves that were never intended to be used as Class C R.F. amplifiers anyway. Nowadays, a wide selection of R.F. power amplifier valves is available—so wide in fact, that the choice is rather embarrassing, and we sometimes have difficulty in making up our minds just which we will use. Pentodes for transmitting have come into their own, but there is still a good deal to be said for the neutralized triode. At least it makes no pretence to not needing neutralization, and does not give us the nightmare of trying to decide whether it is under or over-neutralized or whether a bit more shielding (that our lay-out gives no room for!) would not have cured the instability! For this reason we will think in terms of triodes for this article.

To get back to the question of choosing a suitable tube, it is not as easy as all that. The one we want may not be available, or may be too costly for our attenuated pocket, and we may have to make do by choosing the best one for the purpose out of existing stocks, perhaps borrowing it from the main transmitter for the purpose.



A view of the completed 35TG *stage. The tuned circuit in the front is the essential part of an unusual neutralizing circuit whose functioning and adjustment are described in the text. The lay-out of the stage is also described in detail.*

But the whole thing can be boiled down to one question—what is the proposed tube's maximum working frequency? If it is considerably higher than the frequency on which we wish to work, so much the better. If the maximum frequency for full ratings is only a little higher than 54 mc/sec., we will be O.K. If it can be worked at reduced ratings on six metres, we will get by, but if the greatest usable frequency is lower than six, then it cannot be used at all. Below is a list of some popular tubes and their frequency ratings.

Valve Type.	Max. Freq. Full Ratings mc/sec.	Max. Freq. Reduced Ratings. mc/sec.	Suitability for 6m. use.
809	60	120	Good
808	30	130	Satis.
811	60	100	Good.
812A	30	100	Satis.
826	250	300	Excellent
834	100	350	Excellent
W.E.316A	500	—	Excellent
8012	500	—	Excellent
T20	60	—	Good
TZ20	60	—	Good
25T	60	—	Good
24G	150	—	Excellent
T40	60	—	Good
TZ40	60	—	Good
HK54	100	—	Excellent
35T	100	—	Excellent
35TG	100	—	Excellent

From the above list, it can be seen that as far as the 50–54 mc/sec. band is concerned, almost any modern amateur tube can be expected to perform well. The question then reduces to choosing the most satisfactory one, if a number of types is available. This is simply done by picking the tube with the highest frequency for maximum ratings. It should be emphasized that this has nothing whatever to do with whether or not you intend to use them at maximum ratings. It is simply an indicator of the efficiency one can expect, and the ease with which the driving power may be obtained at this relatively high frequency. Other things being equal, the tube with the highest frequency rating will operate more efficiently, and will take less driving power than one which is worked beyond its maximum frequency for full ratings. These remarks apply equally well to work on any high frequency, and should be generally helpful as a guide to choosing a tube for any higher band.

NEUTRALIZING

Another difficulty that we might expect to encounter at high frequencies is that of inefficient neutralization. This in turn depends to some extent on the circuit used—plate, grid, coil, link neutralizing, etc.—but depends most of all on the lay-out of the stage, and upon certain of the components, such as the plate tank condenser. With a suitable arrangement of parts, and with suitable parts used, neutralization will not be any more difficult at V.H.F. than lower down. In fact, for some purposes, the triode is definitely superior to the pentode, and one of them is that compared with "sitting down" a recalcitrant pentode stage, which is supposed to work without neutralization, but does not, neutralizing a suitable triode is child's play. We will have more to say about this aspect later when we come down to practical cases.

CHOICE OF PARTS AND THEIR PHYSICAL ARRANGEMENT

It is here that the real secret of building a high-frequency power amplifier lies. A very short glance at some high-frequency circuits will show that the circuits are often identical with those that are so easy to get going at lower frequencies. This means that any differences in performance can be due only to the type of components chosen, and their physical arrangement. For instance, it would be of no use whatever for us, or anyone else to write an article on V.H.F. power amplifiers describing only the theoretical circuits.

What then, influences the choice of parts, and why or how should they differ from those used lower down the frequency scale? As everyone knows, one of the greatest difficulties in getting a receiver or anything else to work on higher and higher frequencies is in arranging things so that it is possible to use a respectable ratio of inductance to capacity in the tuned circuits. This difficulty shows up in its worst form when one is modifying an existing arrangement for a higher frequency, simply by winding new coils with fewer turns. A stage is reached where we are left with virtually no coil at all, and our condensers at minimum capacity. If we have reached the desired frequency, then the performance, be it receiver, transmitter, or what you will, is very disappointing. Large amounts of grid driving power disappear into the blue with no visible results in the way of grid current, circuit Q becomes so low and losses generally so high that everything tunes in a very flat fashion and plate current dips under no purposeful load are non-existent. Power output, too, under these conditions becomes negligible.

This state of affairs can be due to a number of things, but the chief offenders are high minimum capacities and high lead inductances. The average large tank condenser as used in low-frequency transmitters is much too large and bulky to use at any frequency higher than 30 mc/sec. and very frequently is quite poor even at ten metres. The large physical size has several effects. First, and most obviously, it means a large minimum capacity. Secondly, but not so obviously, it means a large inductance. Any conductor has a certain amount of inductance, even if it is large in dimensions and is shaped like the stator-plates of a condenser. Thus, when we construct a tank circuit, and attach the plate of the valve to one stator lug on the condenser, and the coil to the lug on the opposite side of the same set of stator plates, we may be inserting so much inductance in series with the coil and the plate of the valve that the coil has to be much

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too small for efficiency. If we add to this the inductance of say three inches of lead between the condenser and the plate terminal of the valve, we find to our cost that so little of the real circuit inductance is represented by the coil that it is not possible to couple from it what R.F. energy may be there. Now stray capacities and inductances are notorious for having very high losses, so that we end up with a very inefficient circuit, even though it may tune to the desired frequency.

There is only one way to deal with this sort of thing, and that is to use small components, preferably designed for use at very high frequencies. Fortunately, such components can be bought today over the counter at radio shops as a matter of course. There is in particular an excellent line of small condensers, suitable for V.H.F., which is readily available in singles, two-gang, and proper split-stator types. They are also made in two values of plate spacing, so that for plate voltages up to 1000, they can readily be used in transmitting circuits, even though they are physically no larger than receiving midget variables. The condensers used in the illustration on this page are all from this line. They are ceramic insulated, the plates are silver-plated, the bearings are solid, and, in fact, they are excellent in every way. As an object lesson, this photograph would be hard to beat. Just look at the coils, and reflect that the frequency is 50–54 mc/sec. The topmost one is the plate tank coil. It is NOT a balanced tank circuit; it is connected directly across the output capacity of the valve, and yet the coil consists of eight turns one inch in diameter! The other two that can be counted are those of a two-turn coupling link for extracting the output. Having decided to use variable con-

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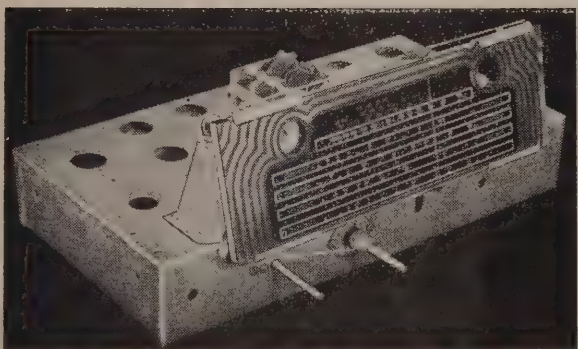

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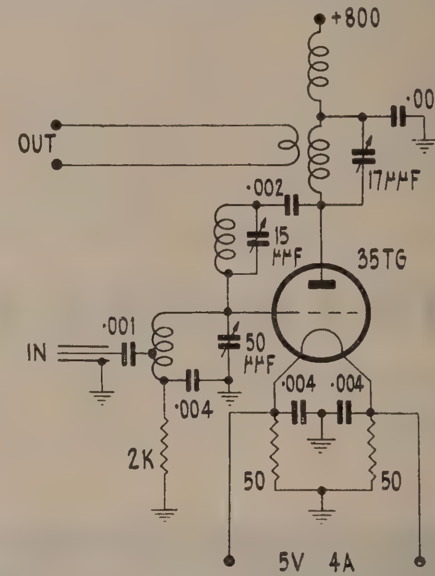
densers suitable for the frequency, then all that remains to ensure success is to lay out the stage so that (*a*) the tuned circuits form compact units, and (*b*) the interconnecting leads between the tuned circuits and the valve are as short and direct as possible. A third consideration is important, too; all bypass condensers should be mounted as close as possible to the points which they are meant to bypass, and a single earth-point should, if possible, be used for the whole stage. The latter ensures that losses are not incurred through R.F. currents having to flow through the comparatively high-resistance material of the chassis. One of the worst things that can be done is to separate the coil from its associated condenser when making up a tuned circuit. This passes the high circulating current of the circuit through part of the chassis, and results not only in heavy losses, but also in undesired coupling between one part of the circuit and another. As frequencies become higher and higher, this is more difficult to achieve, but at six metres the problem can easily be solved by using as compact a lay-out as possible, as exemplified in the photograph.

OUR OWN EXPERIMENTAL SET-UP

In order to demonstrate the above principles in a practical way, and also to prove the worth of a somewhat unusual neutralizing arrangement, we built in our laboratory a Class C amplifier for the 50–54 mc/sec. band using a 35TG which we happened to have about. There is no reason why the same circuit should not be used with any of the suitable tubes in the table above. Valves which, like the 35TG, have the plate brought out to a pin on top of the valve, and the grid to a similar pin on the side of the envelope, can be used with the identical lay-out as shown in the photograph. Since the circuit is somewhat unconventional, and in some ways influences the physical lay-out, it might perhaps be better if we described the circuit first.

THE CIRCUIT USED

To a large extent, the design of the whole amplifier revolves round the neutralizing arrangement; this is usually known as "coil neutralization," and the system used here is a slight modification of it. The grid and plate circuits are conventional, with L/C ratios in keeping with the tube and its characteristics. The filament circuit also is quite usual, and output is obtained from the plate tank by means of a two-turn link coil closely coupled to the "cold" end of the plate tank coil. The neutralizing circuit comprises the 0.002 μf. blocking condenser, and the third tuned circuit. This, like the plate and grid tanks, is tuned to the signal frequency, and provides neutralization in a very simple way. It is well known that a parallel-tuned circuit acts as a very high impedance at its resonant frequency. This impedance is a pure resistance exactly at resonance. Now the purpose of any neutralization scheme is to prevent energy at the signal frequency from being fed back to the grid from the plate circuit. Although the grid-plate capacity is very small in most good transmitting valves, and is particularly so with the 35TG, it is not small enough to prevent the valve from acting as a T.P.T.G. oscillator in the absence of neutralization. The most commonly used neutralizing systems, known as grid and plate neutralization respectively, are simple bridge circuits, in which no attempt is made to prevent the feedback from plate to grid, but the effect of the feedback is cancelled by feeding back a second voltage equal in amplitude, and exactly out of phase with the inter-electrode feedback. The net result is that no R.F. voltage now exists on the grid because of the presence of the plate circuit. In pentodes, an attempt is made to remove the necessity for neutralization by shielding the grid electrostatically from the plate with the screen-grid, so that no R.F. voltage can get to the grid in any event. The present scheme is similar, except in so far as it behaves rather better than most screen grid valves, and gives to all intents and purposes perfect neutralization. There is no R.F. voltage at the grid of the valve simply because the impedance of the tuned circuit connected between grid and plate is



Circuit of the amplifier. Although a co-axial line is shown as the input feed, there is no reason why an ordinary link should not be used in the same way, with the blocking condenser to prevent the link from short-circuiting the bias resistor.

so high that no voltage can be developed there. Most circuit diagrams illustrating this method show the blocking condenser and coil, but no parallel capacity as we have used here. The books state that the value of the inductance is adjusted until it resonates with the grid-plate capacity of the valve. However, it is much easier to add a variable capacity in parallel and then adjust this, rather than to adjust the inductance, and this has been done.

NEUTRALIZING PROCEDURE

With the above arrangement, the procedure for neutralizing is the same as with any other system. Grid drive is applied, but no plate voltage. First, the neutralizing circuit is removed from the grid, and the plate tank condenser is tuned through resonance after the grid tuning has been adjusted for maximum grid current in the usual way. Then, the neutralizing circuit is reconnected and tuned. Resonance will be indicated approximately by the rise of grid current. (You will remember that with the tube unneutralized, and the plate circuit in resonance, a large drop in grid current takes place.) After a preliminary adjustment of the neutralizing condenser, the plate circuit is again tuned through resonance, and it will be found that the flick in the grid current is much smaller than before. The neutralizing condenser is then adjusted slightly, and further tuning done with the plate condenser. Very soon, a point will be found at which no observable change in grid current takes place when the plate circuit is tuned through. This is exactly the procedure used for neutralizing a plate-neutralized stage, but here there is one important difference. *It is possible to adjust the neutralization to be so nearly per-*

fect that when the plate tank is tuned through resonance it is impossible to tell where the point of resonance is.

Now this, to our way of thinking, is real neutralization. Why, you may well ask, has this system been so neglected in the past? Unfortunately, there is one very good reason. It is this: that the scheme is not a broad-band one. That is to say, for all but very minor frequency changes, it is necessary to re-neutralize. Perhaps this will be sufficient to discourage many from using it, but it should not be, when it is considered how easy and perfect neutralization becomes. In multi-band rigs it would certainly be a nuisance having to plug in a third tuned circuit to the final, but the most awkward thing of all would be having to re-neutralize when using a V.F.O. However, for applications where rapid frequency changes are not needed, it has no disadvantages at all, and its advantages are such as to make it worth while to go to a little trouble to use it. For example, the man who uses, say, two or three crystals for the 80m. band, would not find it difficult to make up for each crystal a plug-in neutralizing circuit, pre-tuned and marked with the crystal frequency. For V.H.F. bands, where it is perhaps not so essential to be able to change frequency rapidly, this circuit is ideal. Some of the more conventional arrangements will not work at all at very high frequencies, but with this one, everyone can be sure of excellent neutralization and of the advantages which it brings.

One recommendation of the method is that broadcast stations which generally have no QSY troubles to contend with, use it a great deal. Now in a broadcast transmitter it is essential to have as good neutralization as possible, because low distortion is not possible without it. That should speak for itself.

THE LAY-OUT

The photograph gives a very good idea of this. Unfortunately, the join between the chassis and the front panel has not come out very well owing to the black crackle finish, but it can just be glimpsed, running parallel to the top of the panel, which just shows in the top right-hand corner of the picture. Mounted on the four long bolts is a small panel of bakelized sheet. This carries the plate tuning condenser, and also one or two solder lugs riveted to it. One can be seen attached to the light-coloured H.T. wire running down through a hole in the chassis. It acts as a tie-point for this wire and for the R.F. choke. It was thought advisable to insulate the small plate tank condenser, because in a stage which could have up to 1000 volts on it, the 0.045 in. spacing is not very great when it comes to carrying D.C. and R.F. as well. The connection shown makes it necessary to use an insulated operating shaft, but has the advantage that only the R.F. voltage appears across the condenser, which is then much less likely to flash over when the stage is lightly loaded, or on no load at all.

The neutralizing circuit is the one nearest the front in the photograph, with the axis of the coil vertical. The strong light makes it look as if the bracket is a metal one, but it is of the same brown fibre as was used to mount the plate tank condenser. It is held to the chassis by a small aluminium bracket. The large mica condenser is the 0.002 μf. blocking condenser, and is so placed that only a short lead is needed to the plate pin on top of the valve. The valve is so placed that the grid pin runs parallel to the front panel. It is unfortunately hidden in the photograph, but one can just see the clip that connects it to the flexible lead from the grid circuit. This is mounted on the front panel, as close as possible to the valve. The stator is on the left in the photograph, and to

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	215SG	EF39	OM6, OM7
PM22A	220HPT	EF91	SP6
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OUR GOSSIP COLUMN

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On 1st August last every one of Philips Electrical Industries' staff had a definte festive air about him and the reason for this was that the day marked another milestone in the career of their popular Managing Director, Leighton Lord.

It was on the 1st August, 1925, that Leighton Lord first joined the Philips organization in Australia and preparations were well in hand to commemorate his silver jubilee in a memorable fashion.

There was a cocktail party attended by Philips staff for the purpose of making the various presentations. Mr. J. H. Brooks, when presenting Mr. Lord with a handsome silver tea service, paid glowing tribute to Mr. Lord's many qualities and of the friendship they had enjoyed over many years. Mr. Undrill, factory manager, made a presentation of a silver tray on behalf of the factory staff. A beautiful woollen travelling rug was presented by the Secretary, Mr. McNeil, on behalf of the commercial department. The Philips Social Club, in recognition of many past favours, presented Mr. Lord with an attractive barometer. This presentation was made by lighting manager, Mr. Kerr, who is chairman of the club.

Also present at this gathering was Mr. F. N. Leddy, Governing Director of Philips, Australia, who on behalf of Mr. Lord's many Australian friends presented him with an artistic silver cigarette box. Following this, Mr. Leddy, on behalf of the Philips Board of Management in Eindhoven, presented Mr. Lord with a magnificent gold watch as a token of their appreciation of his twenty-five years of loyal service.

Many expressions of appreciation of Mr. Lord's loyal service and popularity were made by several speakers and in reply Mr. Lord, visibly moved by the many tributes, both oral and material, said that mere words on this occasion could not possibly express how much he appreciated the many beautiful gifts and that the function was a complete surprise to him. He went on to review his progress with the company from the early days and finished by saying that he was proud to be part of the New Zealand Philips team and felt it was no small honour to have completed twenty-five years' service with an organization such as Philips.

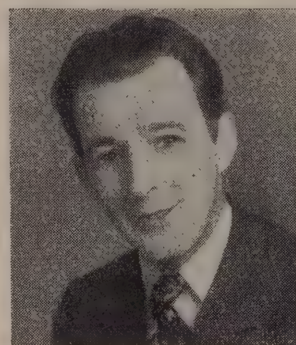
The cocktail party was followed by a dinner party at the Royal Oak after which an enjoyable evening was spent at the Opera House viewing the "Oklahoma" show.

* * *

Squadron Leader J. W. Todd, M.B.E., Deputy-Director of Signals, R.N.Z.A.F. Headquarters, has been appointed to the Joint Services Liaison Staff of the United Kingdom as the Services Signals representative for New Zealand. S/Ldr. Todd was a frequent visitor to R. & E. and will be missed for his cheery chats in the lab. there. The immediate past president, and a foundation member of the N.Z. Electronics Institute, his absence from New Zealand for two years, though a loss for the time being, will be more than compensated for by the experiences he will have to tell when he again resumes active membership.

* * *

A happy gathering took place at Green & Cooper's to wish Don Cooper bon voyage on the eve of his departure for Australia and England last month. Among those present were Ian Gow, Roy Simon, Rex Cassey, Herbert Dixon, Jack Madaver, Stan Shea, Tom Duxbury, Roy Olen, Stan Wrigley, Alan Webster, Max Tovey, Pat Brown, Guy Leatham, Doug Foster, Alec Ayton, Ernie Tilley, Ted Palmer, Gil Hill.



Rev. Grover, managing director of Grover Electrical Co., has left on an extended trip to Australia. Rev. says that he has promised himself this trip for a long time. Now, with Ivan Cosgrove at the helm of sales he can go away with some peace of mind.

Colin W. Smith (Sales Manager, Rola Co. Australia), meets Radio & Electronics in an informal talk on radio matters generally, and peruses the current issue of R. & E. Mr. Smith is on a visit to New Zealand on behalf of his firm and has toured the territory with Mr. W. B. Blackwell (Swan). Accompanied by Mrs. Smith, this is their first visit in the 17 years since they left the shores of New Zealand for fortunes afield in Australia, so that reunions of relations and friends have been much enjoyed. The older members of the radio industry will remember Colin Smith as associated with "N.Z. Radio Times" which served the radio trade here for several years prior to 1933, and of which Colin was the initial editor. Thus additional interest was added to his trip in learning of the up and downs of present-day publishing of radio news and data.

In the picture from left to right are: Chas. Roser (R. & E.), Colin Smith, Doug. Foster (R. & E.), and Wm. Blackwell (Swan).

* * *

Recent visitors to Wellington include Dick Tyler from Napier, and Roly Magness of Auckland.

Mike Pointon (Fears) took unto himself a wife in August. Many congrats. Mike.

* * *

Friends of Allen Jones (Nat. Elec.) will regret to hear of his indisposition in hospital. Our best wishes, Allen, for your speedy return to the old crowd.

* * *

Our sympathies are extended to Les Chaston, whose father recently passed on.

* * *

Popular Dave Clark, Assistant Secretary, Manufacturers' Federation, has recently announced his engagement. Congratulations and best wishes Dave.

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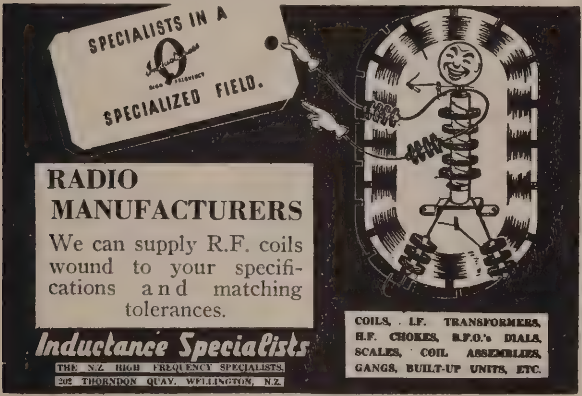

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The PHILIPS Experimenter

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No. 35: A Low-powered Transmitter or Exciter for Six and Two Metres

PART II

In Part I of this article, the circuit and principles of the R.F. section of the transmitter/exciter were dealt with in some detail. Since some rather unusual features are incorporated, this part will be devoted to describing in detail the adjustment of the circuits, from the multiplier-type crystal oscillator to the π-section output coupling circuit. Experimenter No. 36 will describe a power supply and modulator unit which will make the whole into a self-contained low-powered transmitter for 'phone or C.W. Those who are interested, therefore, only in using the R.F. section as an exciter for a medium or high-powered final will find all they need in the last and present instalments. For the R.F. section a small power supply delivering 250 volts at 80 ma. will suffice, and any power pack of this rating will do as long as the filtering is reasonably good. In many cases users will be able to employ an existing receiver power supply where this is made as a separate unit. Modulator requirements are quite light, also, and any audio amplifier able to deliver 6¼ watts at the secondary of a suitable modulation transformer will provide 100 per cent. modulation of the QV04/7 with excellent linearity. A point to note here is that, unlike most transmitting pentodes, the QV04/7 is operated with identical plate and screen voltages. Thus, there is no waste of power in a screen dropping resistor, and exceedingly linear modulation is obtained. Plate and screen together draw 50 ma. or thereabouts, so that the required secondary load impedance for the modulation transformer to work into is 5000 ohms. This, incidentally, is a very suitable value for using the old but excellent Heising modulation system, which has its points for low-powered stages, since the expense of the modulation transformer is almost eliminated, a simple modulation choke being used instead. However, we will go into this question in more detail later on.

ADJUSTING THE OSCILLATOR

As was mentioned in Part I of this article, the oscillator circuit required rather more care in adjustment than the usual crystal oscillator, because here there is the possibility that the circuit may oscillate, but NOT controlled by the crystal. It is not difficult to avoid this condition, but adjusting the circuit in the proper way in order to make absolutely certain that it is not oscillating freely is a "must."

Ideally (and this type of operation will be obtained in some cases), the circuit oscillates only when the condenser C_1 is tuned very close to the third harmonic of the crystal frequency, and when C_1 is very slightly mistuned, oscillation ceases. When this happens, all is well, and there will be ne need after initial checking to give much thought to the matter. With some crystals, however, it will be found that, though the oscillation locks in to the crystal harmonic quite readily, the circuit continues to oscillate when the condenser is de-tuned. Even then, though, operation is quite satisfactory, because when the correct setting is found for C_1, the oscillator will come on under proper control every time it is switched on. The latter, less desirable type of operation is thought to be due to the fact that some crystal holders have much more capacity than others. In fact, the only crystals which were found to behave in this way were those of the old large-holder type, which plugged into a 5-pin valve socket. The modern small-holder type, which plugs into an octal socket, does not, as far as we have been able to observe, behave in this way at all, but gives a definite gap on each side of the crystal frequency, where the circuit does not oscillate at all. The critical part of the circuit adjustment is that which concerns finding the right place for the tap on L_1. In order to carry out the process to be described, a beat type frequency meter is necessary. If one is not available (though there should not be a ham shack without one) one must build up a temporary oscillator for the purpose. This should have a tuning range from 24 to 27 mc/sec., should be stable enough to handle easily, and should have a detector of some sort incorporated so that the beat note between the crystal oscillator and the adjustable one can be heard in a pair of 'phones. A weakly-oscillating detector will do quite well, so that the detector of a regenerative receiver will do the job if such a thing is available. Whatever is used as the beat-frequency meter, this should be tuned to somewhere near the output frequency of the oscillator circuit, and the latter turned on. With one eye on a 0–50 ma. meter in the plate circuit of the oscillator section of V_1, and the phones on, C_1 is slowly tuned. When a flick is noticed in the plate current of the oscillator, this probably indicates that the plate current is tuned to the third harmonic of the crystal, and C_1 should be set to that spot. The frequency meter is then tuned until it is heard to beat with the oscillator. It is left set so that a fairly high beat note is heard in the phones, and the effect is observed of retuning C_1 very slowly through a small range. Should we have struck the controlled oscillation first time, we will find that an appreciable adjustment of C_1 can be made without any noticeable change in the beat note. As C_1 is further moved, the beat note either disappears suddenly, or else changes suddenly to a different frequency, indicating that the oscillator is no longer controlled by the crystal. What we hope to find is that after the beat note disappears, due to our careful de-tuning of C_1, the circuit has ceased oscillating. To test this, we therefore tune the beat frequency meter slightly about the original setting, and see if we can pick up the oscillator again. If we cannot, then it is one indication that oscillation has stopped. A further check is to see what happens to the plate meter at the same time as C_1 is being adjusted. If oscillation stops as soon as C_1 is removed slightly from the crystal frequency, the fact will probably show up as a sudden rise in plate current.

The next thing is to check the operation on the other side of the crystal frequency. If the behaviour is the same, *i.e.*, oscillation stops suddenly after only a negligible change in beat note, then we can assume that within the small range over which we have adjusted C_1, the circuit oscillates only when the circuit is tuned to the crystal harmonic. The oscillator will then behave just like an ordinary crystal oscillator, and setting it up permanently will consist simply in adjusting C_1 to the best spot within the oscillation range. Like most crystal oscillators, this circuit has to be set slightly on the

low-capacity side of the point which gives maximum output. If it is set *at* the point of greatest output, the chances are that it will not start again after it has been switched off.

Of course, it is not very likely that the initial adjustment will be found as easy as we have just described. This is because the coupling between the tickler portion of the coil L_1 and the tuned part, has to be carefully adjusted before the right kind of operation is secured. It is more than likely that when the oscillator is first swtiched on, it will oscillate strongly at all settings of C_1, or else will not oscillate at all. In the former case, the coupling of the tickler is too tight and will have to be slackened off. In the latter, not enough coupling is indicated.

Now there are two ways of altering the coupling between the tickler and tuned sections of L_1. For coarse adjustments, the turns below the tap can be spread or squeezed together slightly. It will be found that an adjustment of one whole turn in the position of the tap will probably make all the difference between too much and too little coupling, so that the final adjustment has to be made by altering the spacing, as suggested. When the circuit is correctly adjusted, it will be found that on the high-capacity side, C_1 may be de-tuned as far as we please without uncontrolled oscillations developing, but that on the low-capacity side, free oscillation commences some little distance from the crystal frequency. This is perfectly normal for the circuit, and does not indicate a fault.

With high-capacity crystal holders, as mentioned above, it will possibly be found that continuous oscillation takes place all over the range of C_1, locking taking place when this condenser is set near the crystal frequency. This sort of operation is also permissible, but obviously more care is needed to ensure that the oscillation is crystal-controlled at the final setting chosen for C_1. Under these conditions, the coupling is a little more critical to adjust, but when it is correct, the free oscillations are considerably weaker than the controlled one. This decrease of output, as well as the sudden frequency shift when going from controlled to uncontrolled oscillation, acts as a ready indicator of what is happening. It should be remembered that one should always check the setting of C_1 to see whether self-starting is obtained. After the oscillator has been switched on and adjusted to the locked frequency with the frequency meter, it is quite possible that the C_1 setting will not allow the locked oscillation to restart, and that after switching off and on again, the free oscillation is obtained. We would like to emphasize that this sort of thing can always be taken

(Continued on Page 30.)

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(Continued from Page 21.)

the right can be seen the 0.004 μf. mica condenser which is used between the cold end of the grid coil and the rotor of the condenser. This is firmly soldered to the stout rotor wiper, and the coil is soldered directly to its other end. The grid leak resistor can be seen directly under the coil. At the extreme right of the picture can be seen the co-axial input cable, which is run in the corner between the chassis and the panel. The end is bared for half an inch or so, and the 0.001 μf. blocking condenser is soldered to it. The other end of this condenser is soldered on to the appropriate tap on the coil. Note the earth lug which is visible directly under the neutralizing coil. All earths in the stage are taken to this lug, or to another one under the chassis, fixed by the same bolt. The plate bypass condenser cannot be seen, but is taken from the rotor of the tank condenser vertically downwards behind the valve, and its bottom lead bent to attach to the common earth point. Both this condenser and the 0.002 μf. blocking condenser in the neutralizing circuit should be rated at 1500 volts at the very least, and higher if one is going to put 1000 volts on the stage.

DRIVING REQUIREMENTS

One of the difficulties often encountered in operating a medium or high-powered stage at a fairly high frequency is that of obtaining sufficient driving power. Very often, as we said earlier, this is due to the use of inefficient valves or circuits in the high-powered amplifier, but equally often it is due to either the improper choice of a tube for the exciter stage or to poor matching between it and the final. IT IS JUST AS IMPORTANT TO CHOOSE A SUITABLE VALVE FOR THE DRIVING STAGE AS FOR THE FINAL. It is also important to see that efficient coupling arrangements are made for taking the output power of the driver and converting it into useful grid current for the final. These days there are a number of valves which will work well at six metres, and will produce several watts, which will be needed to drive a stage like the one we have been describing, irrespective of the exact tube type used in the final. One reason for choosing the 35TG as a valve for illustration of the principles involved was that it appears to be quite difficult to drive, requiring a high grid current through a low value of grid leak, and an input of several watts. At the higher frequencies, efficient power transfer from the driver is even more important than usual, because, unless we are prepared to run grossly inefficient low-powered stages, capable of throwing away in losses a good deal more power than the final actually needs, it is not the easiest job in the world to get the drive we want.

To return to our present example, we find, if we look up the data sheets, that the 35TG requires a driving power of 7 watts when used with a plate voltage of 1000, and a plate input power of 125 watts.

We did not have a 1000-volt power supply available in the laboratory, the most we could raise at short notice being about 800, so that our calculations were based on this voltage, and on an input power of about 60 watts. This is approximately half the tube's rating, so that one can expect that the quoted figures for grid driving power and D.C. grid current will be approximately half those given. This means that for 800 volts at 70 ma., an input of 56 watts, 3.5 watts of driving power, with 20 ma. of grid current would give the excitation that was wanted. This turned out to be very convenient. We happened to have an exciter unit on the bench which ended up with a single QV04/7 as a straight amplifier on the six-metre band. This, with 250 volts on plate and screen, gave an output power, measured into an actual load, of 3.75 watts. Thus, if this were used to drive the 35TG, it would show whether our assumption about the driving requirements at the low ratings was correct or not. The driver output circuit was arranged to feed a low-impedance co-axial cable, and this was the reason for the input circuit shown. In order to effect an impedance match to the grid circuit of the final, it was arranged that the cable should tap on to the grid tank coil, thereby providing an adjustment that could be used to obtain maximum grid current from the driving power available. The connection is actually made through a blocking condenser so as not to short-circuit the grid bias on the final, which was derived from a 2000-ohm grid leak. The large 0.004 μf. condenser completes the tuned circuit for R.F. current, while allowing the grid leak to develop the 40 volts or so of D.C. grid bias. In practice, it was found that the power output of the QV04/7 was perfectly adequate for the purpose in hand, and that without plate voltage applied to the final, it provided 30 ma. of grid current for the 35TG. This was very encouraging, and all that remained was to see how much the grid current dropped when plate voltage was applied. With the 800 volts on, after neutralization had been done, the grid current was found to drop to 22 ma.—just a little more than the estimated figure. The unloaded plate current was only 25 ma.—a very good figure for the frequency, and an indication that the circuit was going to work at good efficiency. Then the stage was loaded up, and the power output measured. It turned out to be 39.5 watts. From a plate input of 56 watts, this gives an overall efficiency

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(including losses in the output coupling circuit) of 70 per cent.—a very good figure for any frequency, and proof that we had not gone far wrong in estimating the L/C ratios for the three tuned circuits of the final amplifier. The power gain of the output stage was thus 12 db.

ESTIMATING THE RIGHT L/C RATIOS

It should be pointed out that one of the secrets of the success of this amplifier is undoubtedly in choosing the correct L/C ratios for the plate and grid tank circuits. We do not intend to go into this in great detail here, because the amateur literature is full of very convenient charts for working out what the correct circuit capacity —and therefore the inductance—should be for best results from R.F. power amplifiers. But what we do contend is that not enough amateurs take sufficient notice of these charts and their recommendations. Several times we have had inquiries from amateurs who complain that with everything apparently in order, they have not found it possible to load their finals properly, however tightly the aerial was coupled in. Now, this sort of thing can *always* be put down to improper choice of L/C ratio in the plate tank circuit, as long as everything else really is in order. The amateur books quote a working Q of 12 as a suitable figure for using to determine the proportions of tank circuits, and for all ordinary purposes we have yet to find difficulty with an R.F. amplifier if this figure is used.

What determines the Q of the tank circuit under operating conditions is the D.C. plate voltage/plate current ratio. Most of the charts given in the literature are graphs showing the correct circuit capacity to use for each band, for all likely values of the ratio of plate voltage to plate milliamperes, in the final amplifier. The charts can be applied to any stage in the transmitter, and should always be used. What is not so generally known is that they can also be used for finding the correct circuit capacity to use for grid tank circuits as well. The valve operating conditions tell us what the grid bias voltage and grid current should be, so that if we wish to use the charts to find the proportions of a grid tank, all we have to do is to use the ratio of *grid* volts to *grid* mills and apply that to the chart as before. If this is done, *it is safe to say that half the difficulties about not getting enough grid drive disappear.* This, of course, does not apply to the case where direct capacity coupling is done between the plate circuit of the driver and the grid circuit of the next amplifier. If this is done, the single tuned circuit is at once the plate tank of one tube and the grid tank of another, so that if these two require circuits of different L/C ratio, they just cannot be provided when the direct capacity coupling arrange-

Beacon Technical Topics No. 26

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*For use with 50 P 04

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48 C 18	150 ma.	swinging	29/16H	160 ohms
49 C 19	250 ma.	smoothing	14H	100 ohms
49 C 20	250 ma.	swinging	26/10H	100 ohms
48 C 10	350 ma.	smoothing	12H	85 ohms
48 C 13	350 ma.	swinging	18/8H	85 ohms

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ment is used. This is the real reason why capacity coupling is often very inefficient.

However, when any coupling scheme is used which allows of separate tuned circuits for the plate of the driver and the grid of the driven tube, the charts can be used with very telling effect, as they have been here. Many readers will no doubt have wondered why the grid circuit in the 35TG amplifier has such a large variable condenser compared with the plate circuit. The reason is that the grid circuit is a very low impedance one, so that, if the working Q of the circuit is lto be 12, a low L/C ratio must be used.

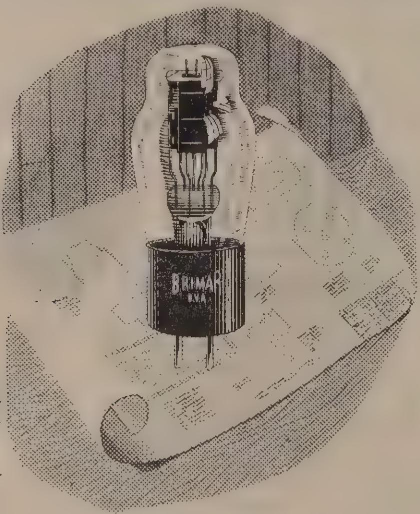
COIL DATA

With the reservations implied in the above paragraphs—namely, than if different tubes are used (other than the 35TG, that is) it may be necessary to use different sized coils to preserve a good L/C ratio—the data on the coils used in our own experimental version is presented below:—

Plate Tank Coil: 8 turns of 20-gauge wire (or thicker). Inside diameter $\frac{7}{8}$ in., winding length $1\frac{1}{4}$ in.
Grid Tank Coil: 6 turns of the same wire. Inside diameter, $\frac{1}{2}$ in., winding length $\frac{5}{8}$ in.
Neutralizing Coil: 10 turns of the same wire. Inside diameter $\frac{1}{2}$ in., winding length $\frac{3}{4}$ in.

CONCLUSION

It is hoped that this article will have helped some of our readers who may have been wondering how best to get high-frequency final amplifiers functioning. The principles are the same whatever the frequency to be used, but as always, stricter adherence to them is necessary the higher one goes. Perhaps the most important point that has been brought out is that such a stage cannot hope to be successful if built as a simple modification to a low-frequency stage. In fact, from 30 mc/sec. up, we have the same problem as we get in receivers—namely, that, for best results, a specially designed circuit is not only advisable, but often absolutely necessary.



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THE NEW ZEALAND ELECTRONICS INSTITUTE (Inc.) NEWSLETTER

1950 EXAMINATIONS

The 1950 examinations for advancement in status will be held throughout the Dominion on Saturday, 14th October, 1950, and entry forms have been forwarded to prospective students. As it is possible, however, that some students may not have received a form, the Institute suggests that immediate application be made for same to the Secretary, P.O. Box 1368, Wellington, as entries definitely close on 16th September, 1950.

For the information of prospective candidates we reproduce below the examination prescriptions and there will be published in the next issue of *Radio and Electronics* a copy of a former examination paper.

It is regretted that due to lack of space it is not possible to publish district news in this issue.

SYLLABUS FOR EXAMINATION PAPER A

General Theory of Circuit Elements

Part I—Electrical Circuit Elements: Production of E.M.F. Effects of an electric current. Units, Magnetism, Resistance. Effects of frequency. Self-inductance—mutual inductance—effects in A.C. circuits. Magnetic coupling. Transformers at power, audio, and radio frequencies. Capacitance—effects in A.C. circuits. Shielding. Resonant circuits. Simple filters. Transmission lines. Calculations in D.C. and A.C. circuits.

Part II—Electronic Tubes and their Characteristics: Action of simple diode. Effect of introduction of third element. Multi-element tubes. Receiving, transmitting and industrial types of electronic tubes. Cathode-ray tubes. Gas-filled tubes including thyratrons, ignitrons, and mercury-arc rectifiers. Light-sensitive tubes.

Special Tubes—For example: Cold-cathode tubes. Electron multiplier tube.

SYLLABUS OF EXAMINATION PAPER B

General Theory of Circuit Elements

Part I—General Applications: Electronic tubes in rectifiers, amplifiers, and oscillators.

Rectifiers—Half-wave and full-wave single-phase rectifiers. Three-phase rectifiers. Smoothing filters.

Amplifiers—Voltage-amplifiers at various frequencies. Power amplifiers at various frequencies.

Oscillators—The electronic tube as an oscillatory generator. Conditions necessary to produce oscillations. Methods of feedback. Frequency stability.

Part II—Specialized Applications: Sufficient choice of questions will be permitted to ensure that each candidate can attempt those relating to his own or an allied branch of electronics.

Radio—Typical continuous-wave transmitters. Modulation—amplitude and frequency. Modulated transmitters, Receivers—broadcast and communication. Aerials—practical types for transmission and reception. Transmission lines at audio frequencies.

Carrier Current and Repeater Systems—Methods and applications.

Industrial Electronics—Indicating and recording devices. Voltage regulators. Speed regulators. Temperature regulators. Electronic heating. Control of resistance welders. Grid-controlled power rectifiers.

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The Philips Experimenter

(Continued from Page 25.)

care of by a suitable adjustment of C_1, which must be left set in such a position that the controlled oscillation re-starts every time after switching off and on again.

As can be seen from the above description, this circuit is not of the absolutely "foolproof" variety that we usually try to present in these Experimenters, but gives a rather wider scope for individual initiative and resource than usual. It is noteworthy that, comparing our results with those quoted in the original Q.S.T. article where the oscillator circuit was described, we found that considerably *less* feedback was needed than the article stated, and that if we used the recommended coil data, the result was invariably uncontrolled oscillation.

The oscillator section's plate current will be found to be between 5 and 8 ma., and that the doubler section of the first ECC91 is provided with approximately 1 to 2 milliamps grid current depending on the adjustment of the oscillator section, and on the tube used.

ADJUSTING THE REST OF THE CIRCUIT

Once one has become familiar with the oscillator circuit and its peculiarities, it will be found that the rest of the circuit is very easily adjusted. The first step is to wind the plate coil for the QV04/7 for the six-metre band, and to get this stage working first. The band switch, S_1 and S_2 is placed in the "six" position, *i.e.,* with V_2 inoperative, and V_3 fed from V_1. The plate coil is plugged in, and C_2 is adjusted for maximum grid current in V_3. After the initial adjustment of V_1 and its circuit, a grid current meter for V_2 will be unnecessary, so that there is no need to provide means of checking this. In order to tune up the final, it is only necessary to couple a small lamp to the plate tank coil, and tune C_4 and C_5 for resonance. Unless the output circuit is actually being used to match the valve to a particular load, the exact position of the larger condenser, C_5, will be immaterial. There will be no difficulty about tuning the final to resonance, so that if a small dial lamp is used as an indicator, it had better not be coupled too closely to the coil or it will be burned out. Most readers will be interested in knowing the best procedure for tuning the π-section output circuit so as to match the required load, and after the indicator lamp has shown that the stage will tune up all right to the required frequency, a suitable load can be applied, and the tuning up tried. If co-axial cable is used to couple the output, as suggested, the best dummy load will be three six-volt dial lamps in series. These can be attached at the output end of the cable, and the tuning and matching procedure can commence. The suggested load will form a fairly good match for any cable that is likely to be used, but only a short length of it should be used for tuning up and demonstration purposes, or there may be a sufficiently bad mismatch for the apparent output to be very low. The adjustment of C_4 and C_5 is really very simple. There will be a wide variety of settings at which these two condensers will resonate the coil at the output frequency, but only one at which they will couple maximum power into the load, and this is the setting that must be found. First, C_5 is set at about half capacity, and the stage is brought into tune with C_4. There should then be some sort of glow in the load lamps. Next, a change is made in the setting of C_5, and resonance is restored by re-adjusting C_4. This done, it is noted whether the lamps glow more or less brightly than before. If more brightly, it means that we have approached the matching condition more closely; if less, then we have taken the adjustment of C_5 in the wrong direction. Thus, the first change in C_5 tells us, after re-tuning with C_4, whether C_5 has been taken in the right or wrong direction. The change should only be small, or the test may give the wrong answer, since we might have overshot the best position. At any rate, C_5 is systematically adjusted, re-tuning each time with C_4, until the greatest power is delivered to the load. We have then reached the matched condition, and the stage is properly tuned up. If the load is the grid circuit of a succeeding stage, the latter's grid current will be the indication of best power output. If the load is an aerial, it will be necessary to use a field-strength indicator to see when the greatest power is obtained. Alternatively, an R.F. ammeter could be connected in the feeder line and matching done for maximum line current. The field strength indicator, however, is safer, because the second method may give a wrong answer owing to standing waves on the line. If an R.F. ammeter is available, the dummy load for testing purposes can be a carbon resistor in series with the ammeter. One can then try the effect of various load resistances, and measure the power output by working it out from the current and the value of the resistor.

When V_2 is in operation, it is necessary to re-tune C_2, because the input capacity of V_3 is no longer connected to the doubler's output. This can be done most easily by reading the grid current of V_3, since as long as C_3 is somewhere near the correct setting, some grid current will show in V_3, and C_2 can then be adjusted for maximum output from V_2. Tuning up the output stage on the 2-metre band is done in exactly the same way as on six.

When adjusting V_3, it will be noted that there is almost no change in the plate current of the valve whether or not excitation is present, and whether or not it is loaded. This is because of the cathode bias resistor, which is there as a protection against loss of load or excitation. This is the reason why an output indicator is essential in tuning up this stage.

The combined screen and plate current for the QV04/7 is approximately 50 ma., subject to slight differences between valves, and the plate current of V_2 is in the region of 25 ma.

(To be concluded.)

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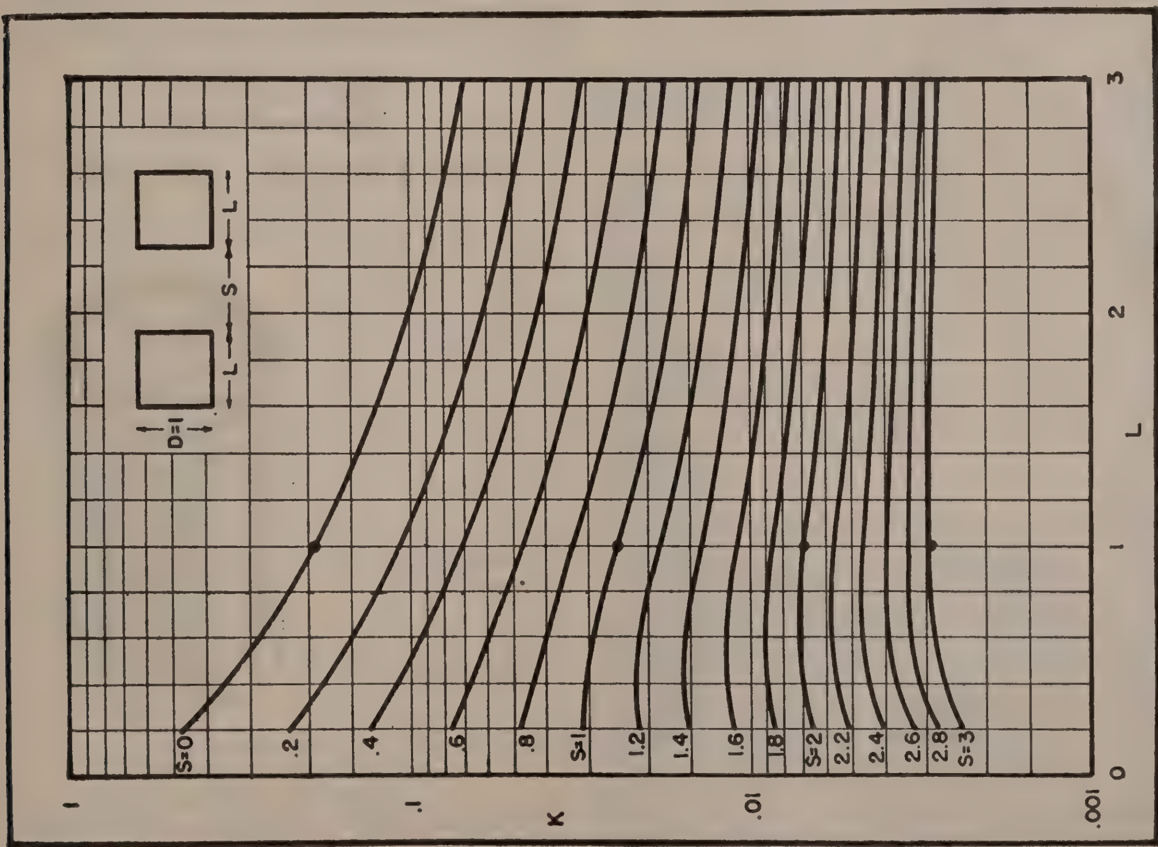
COUPLING CO-EFFICIENT OF SINGLE-LAYER COILS

In many special receivers it is necessary to use an intermediate frequency much higher than that used ordinarily. For example, when a receiver is being designed for frequencies higher than 30 mc/sec., it is desirable to have an I.F. of 4 mc/sec. or higher in order to achieve a good measure of image rejection. Since the image is always removed from the signal frequency by twice the intermediate frequency, it can be seen that raising the I.F. from 455 or thereabouts to 4 mc/sec. will effect a great improvement in this respect. V.H.F. receivers of all sorts very frequently employ this trick, both for image rejection, and because with a high I.F. the selectivity is less, and enables more oscillator drift to be tolerated without the set having to be retuned. If crystal oscillators are used as the local oscillator of a receiver, as when fixed-frequency reception is needed, the oscillator stability is hardly in question, and it then becomes possible to use the high I.F. solely for image rejection, and then to regain the adjacent-channel selectivity by using a second frequency conversion to a lower I.F. One then has the advantage of the high I.F. combined with those of the low I.F.

Another situation in which high I.F.s are often used is when a converter is to be used. This automatically gives a double superhet. type of receiver, in which as a rule there will be two frequency conversions. The first, performed by the converter, changes the signal frequency to a lower one that is within the tuning range of the main receiver. For example, for the best possible reception on 10 metres it is often the practice to use a converter with an output frequency of, say, 4 mc/sec. The main set is then tuned to this frequency, and performs the second conversion to, probably 455 kc/sec.

In all cases where high I.F.s are used, the frequency is usually high enough for single-layer coils to be used as the winding of the I.F. transformers. Good converters usually have a stage of amplification at the first intermediate frequency, so that two transformers are needed. It is not difficult to make a single tuned circuit for a high I.F., but the question of making a suitable transformer is complicated by the fact that two such circuits must be coupled together by the correct amount. Unless one has some idea of the spacing that should be made between the two windings of the proposed transformer, it is impossible even to guess what this spacing should be. This being so, one cannot tell how long the former should be on which the coils are to be wound, or how tall a can is needed to house them. A completely accurate idea of the spacing can be obtained only if the Q of the coils is known, and in general, this will not be known. However, if one takes this as, say, 100, and works out the coupling factor, *k*, from the simple formula below, the result will not be far out. In general, the spacing given by the chart on the basis of a Q of 100 for the coils will be slightly larger than will be needed in practice, since the Q will probably be rather less than this by the time valve and socket losses have been taken into account. In other words, a spacing worked out on this



basis will be the maximum possible that will be needed, so that if the formers and can are made to accommodate this spacing, then one will hardly ever be in the position of not having enough room to get the required spacing in practice. If the Q can be measured, this should be done on a single coil actually in the circuit to be used, as, for example, in the plate circuit of the mixer or I.F. amplifier. A measurement thus made will give the actual working Q, which will in general be only a fraction of the unloaded Q, or the Q measured without valve or circuit losses being taken into account. Then, the accurate Q being known, the *exact* spacing can be got from the chart, which is accurate to better than 5 per cent.

HOW TO WORK OUT THE REQUIRED COUPLING FACTOR "K"

In general, it will be desired to make the coupling slightly less than critical. If it is greater, a double-humped response curve will be the result, and this is undesirable for practically all high-frequency I.F. amplifiers. This is where the Q comes in, because the critical coupling factor k_{crit} is equal to $1/Q$. That is, if Q is 100, then k_{crit} is 1/100, or 0.01. Now the actual coupling factor is a function solely out of the geometry of the coils, and does not depend at all on their electrical characteristics. That is why the accompanying chart shows only k, on the vertical scale, and the dimensions S and L, which are dimensions of the coil, as can be seen from the small diagram within the chart. S is the spacing between the adjacent ends of the coils, and L is the winding length of the coils. The chart refers only to the case where the coils are identical in diameter and winding length. Note that the number of turns on each coil does not come into the picture at all. The coils may have any number of turns as long as the winding length is the same for each. On the chart, S and L are given in terms of the diameter. Along the bottom of the chart L is measured off from 0 to 3, while there are a number of curves, each one for a particular value of S.

If Q is accurately known, it is best to work out the spacing for a coupling factor equal to 0.8 k_{crit}, since this gives maximum gain, and almost maximum selectivity. If the maximum selectivity is needed, without too much loss of gain, then one can work to $k = 0.5\ k_{crit}$. Any further decrease in k has no noticeable improving effect on the selectivity, but reduces the gain considerably.

EXAMPLES OF USING THE CHART

Example 1—It is desired to find the approximate spacing for the coils of a 7 mc/sec. I.F. transformer whose windings will not have a Q higher than 100. The coils will be wound on a $\frac{1}{2}$ in. diameter former, and each is $\frac{3}{4}$ in. long. The greatest coupling factor that will be needed is 0.8 times critical.

Answer—First we must find the coil length in terms of the diameter. The latter is $\frac{1}{2}$ in., and the former $\frac{3}{4}$ in., so that for purposes of the chart, $L = 1.5$. We therefore place a ruler vertically on the chart along the line where L equals 1.5. Now, since we assume the Q is 100, we know that $k_{crit} = 0.01$. Thus, $0.8\ k_{crit} = 0.008$. We therefore draw a line horizontally on the chart at $k = 0.008$, and find that this cuts the line for $L = 1.5$ almost exactly on the curve labelled $S = 1.8$. The required spacing is therefore 1.8 times the coil diameter, or $1.8 \times \frac{1}{2}$ in. $= 0.9$ in. Therefore, the coil former has to be made at least 1.9 in. long in order that the coils may be spaced the requisite amount. Leaving say $\frac{1}{8}$ in. at each end for ease of handling, the former should be 2.15 in. long.

Example 2—The plate winding of a projected I.F. transformer is on a 1 in. diameter former and occupies $\frac{3}{4}$ in. of winding space. The Q under working conditions has been measured as 50, and it is desired to obtain the greatest possible selectivity without too much loss of gain. The coupled winding will have the same diameter and the same winding length. What should the spacing between the near ends of the coils be?

Answer—Since maximum selectivity is wanted, the coupling factor should be 0.5 times k_{crit}. Since $Q = 50$, $k_{crit} = 0.02$. The actual k will thus be half this, or 0.01. Now since $D = 1$ in, and the winding length is $\frac{3}{4}$ in., L for chart purposes equals 0.75. Looking up the chart we find that the intersection of $k = 0.01$ and $D = 0.75$ lies almost exactly half-way between the curves for $S = 1.6$ and $S = 1.8$. The required value of S is therefore 1.7. Since $D = 1$ in., the spacing between the near ends of the coils must be 1.7 in.

The chart may also be used for finding the k being used in an actual transformer as long as the coils are identical in diameter and length. Or, if only a given spacing is available in which to put a transformer, the chart and formulae may be worked in reverse in order to find the greatest winding length that may be used for the coils without exceeding the desired maximum coupling.

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RADIO IN CIVIL AVIATION

By W. S. JOYNER, A.M.I.E.E., A.M.N.Z.I.E.
Chief Radio Engineer, Civil Aviation Branch, Air Department, Wellington

(Continued from Previous Issue)

(I) INTRODUCTION

This is the fourth and last article of this series. The first three have outlined the general developments to date in three of the four general classifications of the International Civil Aviation Organization, *i.e.:*—

(i) Short distance aids to navigation, *i.e.,* up to 200 miles.
(ii) Long distance aids to navigation, *i.e.,* 200 to 1,500 miles.
(iii) Aids to blind landing.
(iv) Aids to air traffic control.

This article will cover aids to air traffic control and give general comments as to the likely future developments.

(II) THE FUNCTION OF AIR TRAFFIC CONTROL

It will be recalled the first of these four articles briefly described the basic operational background to airline operation. Two methods are available, one is by Visual Flight Rules, *i.e.,* with continuous sight of the ground, and the other is by Instrument Flight Rules, in which navigation is by use of instruments, and operations try to be independent of weather conditions from take off to touch down. Complete independence from weather conditions is not yet possible but is a goal towards which aviation development strives.

Where Instrument Flying in itself can provide safe navigation of the aircraft, it cannot provide safe separation *between* aircraft. Such safe separation is especially required around busy airports, particularly under conditions of poor visibility, and this factor is one which is already limiting operations on some of the very busy air routes of the U.S.A.

This simple fact is that air traffic requires its "airways" and its "traffic control" for exactly the same reasons that rail traffic requires its "railways" and its "signalling." Unfortunately, the technical and operational difficulties associated with air traffic are much greater than those of rail and road traffic for aeroplanes must fly through clouds where visibility is essentially non-existent and furthermore they *cannot stand still* in the sky but must always keep moving.

Therefore, they must be provided with accurate navigational aids capable of being rapidly used, must have their movements recorded and displayed in an air traffic control organization and must be controlled always by anticipation.

In practice traffic control is exercised in essentially two forms: en route control, and local aerodrome control. For the purpose of the former, airways are delineated for the main air routes within which all scheduled aircraft must fly, and traffic control centres are set up into which aircraft report their position as they pass over designated check point. From this information it is possible to anticipate where they will be at some future time and by display systems, which in their simplest form are large plotting boards, the general flow of traffic can be controlled. The first essential for such a system is rapid communication facilities between the aircraft and the "centres." Since these centres control comparatively large areas, both air to ground and point to point communication facilities are required. For the first it is obvious that V.H.F. offers the most useful band of frequencies, the apparatus is light, aerial systems are small, radiation can be concentrated in required directions, and multi-channel facilities are readily available; no long range interference is present because no reflections occur from the ionosphere, and above all it is only at those frequencies that static-free radio telephony approaches reality. The restriction to line-of-sight coverage is not so severe since the aircraft naturally have the height. For point-to-point working nothing can supersede line services and generally speaking line teleprinter networks are universally employed for this purpose.

The second form of traffic control is involved in handling the aircraft around and on to the airports. Where density is light, this resolves itself into visual observation coupled with good radio telephony facilities. For the latter V.H.F. R/T is the obvious solution. Where the traffic density is heavy some form of surveillance radar is essential. The operational requirements for such a set are extremely exacting involving coverage throughout the full 360 deg. of all aircraft up to 10,000 ft. in height and up to 30 miles in range. The minimum usable range and height must correspond with a line drawn from the aerodrome up to the height of 10,000ft. at an angle of 25 degrees. The instantaneous resolution of a three

dimensional fix upon all aircraft within such a boundary is patently difficult. The first step being made is to effect a P.P.I. display of range and bearing using a 10 cms set with a reflector giving a narrow beam in azimuth and a cosec^2 beam in elevation. Identification is effected by V.H.F. D/F, the output of which is fed to the P.P.I. display and modifies the related echo in some way such as lengthening. With such a wide coverage required the question of losing echoes by virtue of "clutter" from permanent echoes is very important and in general "moving target indication" is essential. Such a facility was being introduced into search radars towards the end of the war and had its basis in the measurement of the slight difference in time interval between the return from the echo due to its movement. All received pulses passed through a delay system which is exactly equal to the time interval between transmitted pulses. To consider the sequence of events from the emission of any one transmitter pulse is probably the best way of explaining its function. The first echo is received back and passes through the delay to the control grid of a pentode which is normally biased off both on control grid and suppressor grid. The echo also passes to the suppressor direct, but since we are considering the very first pulse after switching on, no signal is present on the control grid and no output is obtained from the anode. When the second pulse arrives at the suppressor the first pulse, for a stationary echo, will simultaneously arrive on the control grid, and the both grids being made simultaneously active, an output will be available in the anode. This output is used to prevent display of such an echo by some suitable means. For a moving echo, the direct and delayed echoes will not coincide, no output voltage will be available and such an echo is not eradicated. Modern techniques have deviated slightly from this principle and are based more upon the actual measurement of the very slight Doppler effect caused by the beating together of the regular ground ray pulse recurrence frequency with the varying frequency of the echo from a moving object. From a fixed target the echo will be repeated at the constant time interval rate, *i.e.*, frequency, of the ground ray and there will be zero beat frequency from such a response. The foregoing is an extremely over-simplified version of a facility that calls for most exactingly reliable measurement of time delays and embraces many difficult problems of circuit design.

(III) FUTURE DEVELOPMENTS OF AIR TRAFFIC

Essentially almost all usage of telecommunication facilities for civil aviation centres around air traffic requirements. In the field of navigational aids it will be necessary to provide parallel "lines" in the airways and permit lateral separation, as well as distance separation along any one track as at present—height separation being a common feature to both. The increased flow of traffic along the airways will only serve to accentuate the problems around the terminals. It has been found that due to variations in meteorological conditions it is impossible to prepare time-tables which can be used as reliable means for such control. By plotting variations between estimated times of arrival and actual times of arrival it has been shown in various airports throughout the world that such a curve is a standard random proability curve, and for high density traffic a random flow has to be accepted at present. Such conditions will not be able to last and experiments are proceeding whereby an aircraft will take off from A after having "booked" an arrival time block, of say four minute units, at B. En route his passage is automatically registered by coded pulses from his distance measuring equipment (transponder) to ground beacons. The ground beacons are V.H.F. pulse linked along the airways and as the aircraft flies along, the fact is automatically registered at B, and by electronic calculation his progress according to schedule is checked. If satisfactory, a return pulse series is used to notify the aircraft; should he be either in front or falling behind this fact will be displayed to the pilot who can take corrective action. With a transponder system, checks can, of course, be made at small intervals of range from the airway beacons and the aircraft may be envisaged as flying in a moving "block." Automatic display such as found in electric totalizators will be essential in the centres.

Such a system of air traffic control may be regarded as visionary but something on those lines must ultimately be produced. Considering the complexity of the problem and the years of development required it calls for most courageous planning and vision by both telecommunications engineers and the operational sections of the civil aviation transport industry of the world and in both the U.K. and the U.S.A. vast programmes of research are in hand.

It may be said that the developments which took place in rail and road transport over fifty years, are being tele-

(Concluded on page 48.)

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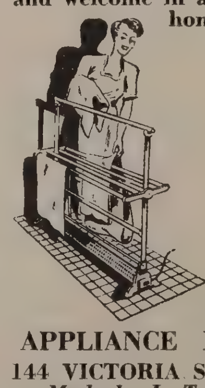

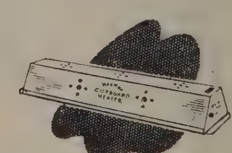

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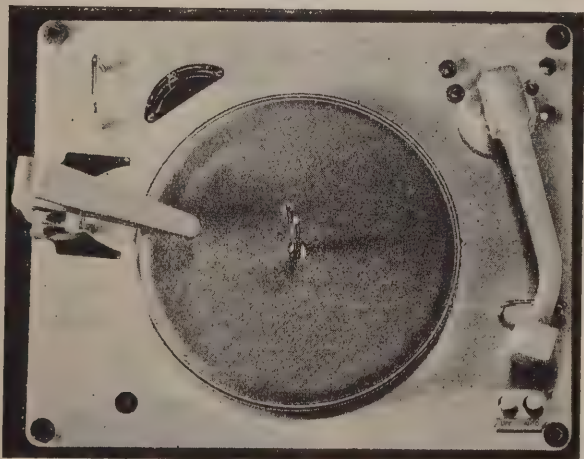

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This imported H.M.V. Autochanger is capable of playing 10 10 in. records or 10 12 in. records which incorporate a quick run-in or eccentric finishing groove. The unit is not of the "mixer" type, and non-standard discs such as 6 in. or 8 in. cannot be played. The lightweight pick-up is specially designed to reduce record and needle wear to a minimum. In addition, by eliminating the prominent treble resonance which is a characteristic of the normal heavyweight type of pick-up, the usual shrillness of tone is avoided, while the upper frequency range has been considerably extended. The pick-up is of the low-impedance type, and must be used with a transformer to match it to normal valve input impedances. The pick-up is a constant velocity device with a sensibly flat response from 50 to 8,000 cycles per second over this section of its total range.

ELECTRICAL DATA

Voltage, 230v. at 50-60 cycles.
Current, 0.09 amps at 250v.
Wattage, 17 watts at 250v.
Resistance of coils, 390 ohms per coil.
Insulation not less than 50 megohms at 500v.

Impedance of coil at 800 cycles, 2 ohms.
Inductance of coil, 140 microhenries.
D.C. resistance of coil, 1.3 ohms.
Output for average record, 6 mV.
Output at Secondary of Matching Transformer of Type 14 Pick-up, 1.5v.

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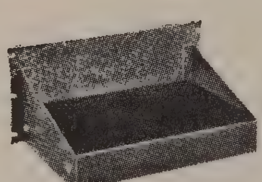

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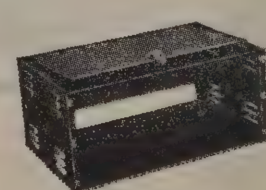

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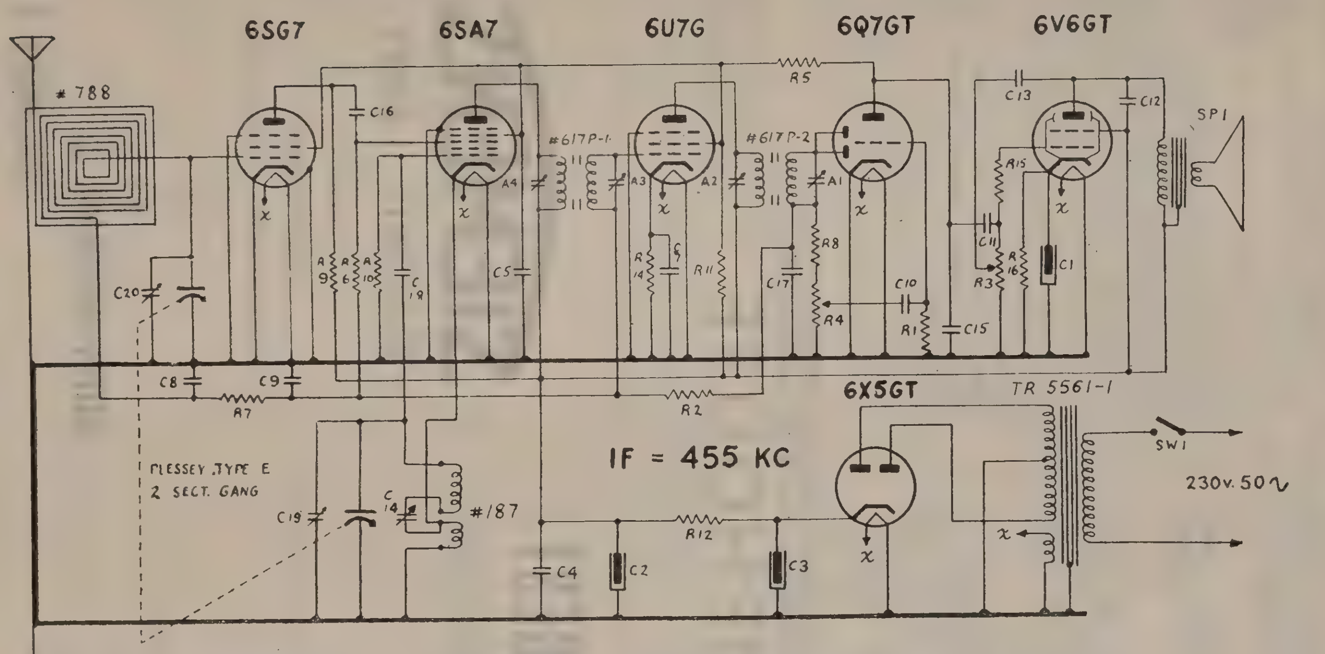

SCHEMATIC DIAGRAM PACEMAKER MODEL 617 P.

VOLTAGE READINGS

Use	Tube	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8
RF.	6SG7	OV	OV	OV	OV	OV	75V	6.3AC	128V
Conv.	6SA7	OV	OV	162V	75V	—2.5V	OV	6.3AC	OV
I.F.	6U7G	OV	OV	162V	75V	O	162V	6.3AC	4.3V
Det-AF.	6Q7GT	OV	OV	35V	OV	O	75V	6.3AC	O
Output	6V6GT	OV	OV	160V	162V	O	OV	6.3AC	7.7V
Rect.	6X5GT	OV	OV	230V AC	OV	230V AC	OV	6.3AC	225V

1. D.C. Voltage measurements are at 2,000 ohm per volt—A.C. Voltage measured at 1,000 ohm per volt.
2. Socket connections are shown as bottom views.
3. Measured valves are from socket pin to common negative.

RESISTANCE READINGS

Use	Tube	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8
RF.	6SG7	O	O	O	1.6 meg	O	30K	O	23K
Conv.	6SA7	O	O	20K	30K	20K	.25 ohm	O	1.6 meg
I.F.	6U7G	O	O	20K	30K	O	20K	O	1.5K
Det-AF.	6Q7GT	O	O	300K	INF	500K	30K	O	O
Output	6V6GT	O	O	20K	20K	500K	500K	O	330 ohm
Rect.	6X5GT	O	O	480 ohm	INF	480 ohm	INF	O	20K

4. Nominal tolerance on component valve make possible a variation of ± 10% in voltage and resistance readings.
5. Volume control at maximum, no signal applied for voltage measurements.
6. Resistance readings in B+ circuits may vary widely according to the condition of filter capacitors.

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D.C. AIRCRAFT MOTOR (G.E.C.); 60v., ½ h.p., 4200 r.p.m. Outside measurements, 10 in. x 6 in. x 6 in. £2/10/-

AERIAL COUPLING UNIT, in case 5 in. x 5 in. x 7 in.; 4.2 to 7.5 mc/s. Ex No. 11 Transmitter (English). Contains 350 ma. H.F. Ammeter, Thermocouple, and Variometer, etc. Cat. No. EX1543 .... 35/-

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- Mullard 165v. Cat. No. EX1554 .... 2/6
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- Feed-Thru, 1½ in. x ½ in. Cat. No. EX1571 2/- each

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BROADCAST RECEIVER TYPE 617P.

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TYPE SET—A.C. Superhetrodyne—self contained loop antenna.

TUBES—(six) 6SG7 R.F. Amp., 6SA7 converter, 6U7G I.F. Amp., 6Q7GT Det-A.F., 6V6GT Power Output, 6X5GT Rectifier.

POWER SUPPLY—230 v. A.C. Rating, 40 watts.

TUNING RANGE—Broadcast, 540-1600 k.c.

ALIGNMENT INSTRUCTIONS

To set pointer, fully mesh variable condenser and set pointer at last reference mark at right end of dial. Set volume control as maximum and keep output from signal generator no higher than necessary to obtain output reading. Use insulated alignment tool for adjusting.

Dummy Antenna	Signal Generator Coupling	Sig. Gen. Frequency	Band Switch Position	Radio Dial Setting	Output Meter	Adjust	Remarks
.1 mfd.	High side to pin No. 8 (grid) of 6SA7. Low side to B —	455 Kc.	....	High freq. end	Across voice coil	A1, A2, A3, A4.	Adjust for maximum output
R.M.A. Standard	High side to ant. term, low side B—	1400 Kc.	....	Tune for max. output	„	C20	„ „
„	„	600 Kc.	....	„	„	C14	Rock variable and adjust for max. output.. Recheck C20 at 1400 Kc. If C20 is changed recheck C14.

CAPACITORS

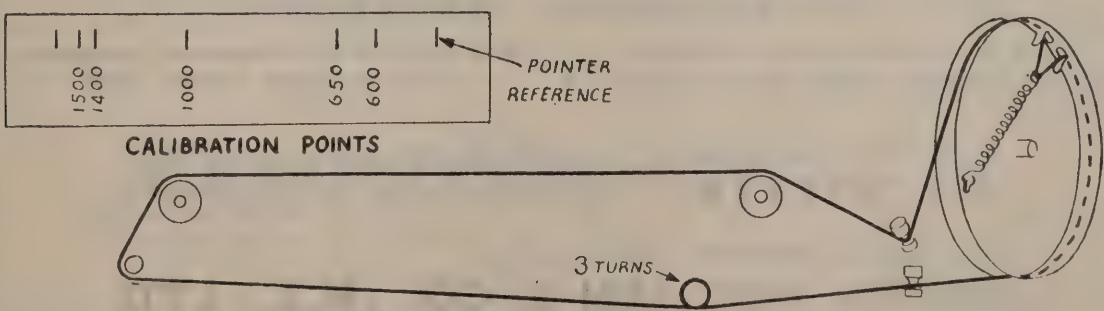
Ref. No.	Cap.	Volts
C 1	25mfd.	25
C 2	20+20mfd.	450
C 3	20+20mfd.	450
C 4	.1mfd.	600
C 5	.1mfd.	600
C 7	.1mfd.	200
C 8	.05mfd.	400
C 9	.05mfd.	400
C 10	.01mfd.	600
C 11	.01mfd.	600
C 12	.004mfd.	mica
C 13	.0005mfd.	mica
C 14	600mmfd.	padder
C 15	.00025mfd.	mica
C 16	.0001mfd.	mica
C 17	.0001mfd.	mica
C 18	.00005mfd.	mica
C 19	3-30	trimmer
C 20	3-30	trimmer

MISCELLANEOUS

Ref. No.	Res., Pri.	Res., Sec.	
788	.04 ohm.	.66 ohm.	
187	.24 ohm.	2.44 ohm.	
617p-1	6.75 ohm.	6.75 ohm.	
617p-2	6.75 ohm.	6.75 ohm.	
	Volts	**Volts**	**Volts**
TR5561/1	230	250 aside	6.3
	Type	**Transformer**	
SP1	6½ P.M.	5000 ohm.	
SW1	S.P.S.T. switch attached to R3		

RESISTORS

Ref. No.	Res.	Watts
R1	10 meg.	½ watt
R2	1 meg.	½ watt
R3	.5 meg.	pot
R4	.5 meg.	pot
R5	.25 meg.	½ watt
R6	15,000 ohm.	½ watt
R7	100,000 ohm.	½ watt
R8	47,000 ohm.	½ watt
R9	5,000 ohm.	½ watt
R10	20,000 ohm.	½ watt
R11	10,000 ohm.	1 watt
R12	1,500 ohm.	5 watt w.w.
R14	1,500 ohm.	½ watt
R15	500 ohm.	½ watt
R16	300 ohm.	1 watt



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BOOK REVIEWS

Television Servicing, by Heller and Shulman. Publishers: McGraw-Hill Book Company.

It has been brought to the writer's notice that in both Britain and America, which can rightly be considered the homes of present-day television, the rapidly growing television industries are in no small degree hampered by the lack of trained service technicians. This must be a very serious situation indeed, because unless manufacturers themselves are to go to the trouble and expense of entering the servicing field on a nation-wide scale, they are going to be seriously affected by an almost complete lack of servicing facilities. Such a situation would be bad enough in relation to ordinary radio receivers, but must be very much worse when it comes to television. The reason is, of course, that a television receiver is an incomparably more complex mechanism than an ordinary radio set, with many times the scope for the occurrence of minor and major faults, not to mention the fact that improper operating conditions can occur from a vastly greater number of possible mis-adjustments, even in a set which has no organic faults at all. Imagine, then, the plight of a manufacturer some of whose sets quite unjustly gain him a bad reputation in certain districts, simply because of the difficulty the owner has in obtaining expert servicing. Television receivers are much more costly yet than ordinary sets, and presumably always will be, so that it may be that a certain amount of difficulty may be met by the makers themselves, by designing the circuits to be less sensitive to adjustment, and less needful of adjustment than they might otherwise be, but such practices must inherently increase the price of the finished article. No one would suggest that a motor-car, also a complicated piece of mechanism, should not periodically have general inspections by expert mechanics, and it is only common sense to assume that the makers of television sets would recommend periodical checks of their products in order to keep their performance on the top line, if the servicemen were available. In television, too, there is even less room for the unprofessional serviceman, who cannot do a worthwhile job, but is able for a time, to charge top prices for his "service" on account of the public's ignorance of the working of the sets.

Luckily, however, the nature of television reception is such that improper servicing can be recognized at a glance by the viewer, be he a technician or not—the eye is a much more sensitive indicator than the ear—so that this sort of sharp practice is much less likely to arise than it did in the earlier days of radio, when anyone who had built a crystal set considered himself competent to service factory-built superhets! There are no doubt many excellent radio servicemen in Britain and America who are anxious to enter the television servicing field, but who have difficulty in assimilating the much wider technical background necessary for this new

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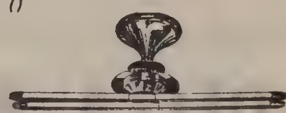
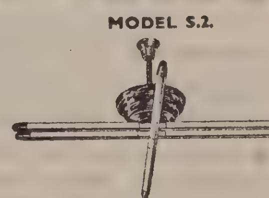
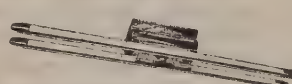


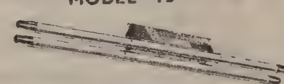
MODEL S.2.



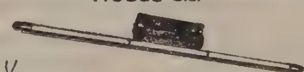
MODEL D3



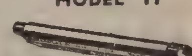
MODEL T2



MODEL C.2.



MODEL T1



MODEL W20

job. This being the case, the publishers of technical books can do much to help by bringing out books designed to help the average good radio serviceman to educate himself up to the necessary standard of television knowledge. The present volume is such a book, and should serve its purpose admirably. It assumes that the average serviceman has not the technical education of an engineer, so that mathematics is eschewed in favour of descriptive analysis very suitable to the type of audience being addressed. This does not mean that anything is skimped. Far from it. The principles of present-day television circuitry are admirably presented in such a way that the practical radio man without strong scientific and mathematical training can understand them, and prominence is given to the analysis of faults by simple observation of the symptoms. In one way, television servicing should be rather easier than ordinary, since the television set has its own oscilloscope built in, and there are many faults which need no more than observation of the set's screen itself for an initial, and even a detailed, diagnosis to be made.

We would like to emphasize that now is not too soon for the wide-awake serviceman in this country to start thinking about television. Those who have absorbed the principles by the time their application to practice becomes a reality here will probably be fairly few and far between, but they will reap a richly deserved harvest. Nor should these far-sighted ones confine their activities to reading about any one system. The differences between the British and American standards are not so great as to make for difficulty in assimilating the details of the other, if one's reading is confined to one system. At the same time, it is wise to keep abreast of developments on both sides of the Atlantic, since television here, when it arrives, will be in a position to take the best of both worlds, as it were, both for decisions on transmission standards, and for receiver manufacturing and design practice.

Questions and Answers in Television Engineering, by Rabinoff and Wolbrecht. Publishers: The McGraw-Hill Book Company.

This book, while bound to become obsolete after some time, aims at becoming a sort of collected reference library on the multitude of topics which affect television practice as it is today, either directly or indirectly. Unfortunately, it makes no reference to television practice other than American. For instance, if one looks up in the index the subject of standard directions for the scanning of the television image, one finds reference only to the American standard video signal. It seems a pity that no text-book on this subject seems to have included information about the technical standards used on the other side of the Atlantic, and this refers to books written on both sides. Television is now a wide enough subject for anything which purports to describe current engineering practice to take in *all* current practice, but most American books on the subject appear to be completely unaware that television broadcasting exists anywhere else in the world. In the writer's opinion, this is unfortunate, since many engineers hope that television will be one activity at least that may be able to get down to some form of international standardization before it is too late, and if the efforts of other nations are ignored completely, it will be very difficult later on to co-ordinate those portions, say, of the signal specifications, which will need to be compatible when it comes to an international exchange of programme material. With everyone going his own sweet way, as at present, very little co-ordination will be possible.

(*Continued on Page* 48.)

DECCA PICK-UP PREAMPLIFIER

Engineered for use with Decca types "C" and "D" pick-ups, this amplifier provides the following:

● Compensation for the complete recording characteristic. ● Four different compensating circuits available by simple switching. ● Compensation based on known recording characteristics. ● Very low distortion and hum level. ● Built-in power supply. ● Average output 2v. ● Uses standard valves*. ● Long switch shaft provides for any mounting position. ● Pick-up plug included. ● Reasonably priced*. ● Available also to order only with high-frequency cut-off filter to the Williamson design.

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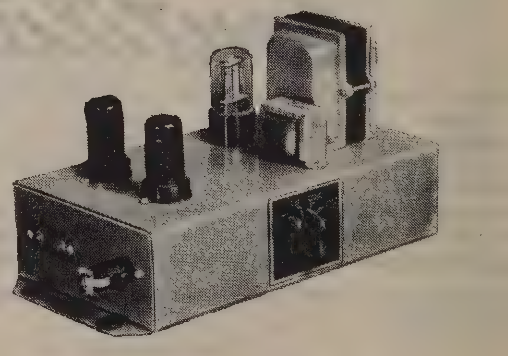

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TUBE DATA: The 35GT—High-mu Transmitting Triode

Elsewhere in this issue there is an article written round the Eimac 35TG. This is an excellent 50-watt transmitting triode, and although it is possible that few, if any, are on the market at the moment in this country, we know that numbers of them have been sold to amateur transmitters since the war, and that their characteristics and operating conditions will be of interest to many.

MODULATOR, OSCILLATOR, AMPLIFIER

GENERAL CHARACTERISTICS

Electrical

Filament: Thoriated tungsten		
Voltage	5.0	volts
Current	4.0	amperes
Amplification factor (average)		39
Direct interelectrode capacitances (average)		
Grid-plate		1.8 mmfd.
Grid-filament		2.5 mmfd.
Plate-filament		0.4 mmfd.
Transconductance ($Ib = 100$ ma., $Eb = 2000$, $ec = -30$)	2850	mmhos
Frequency for maximum ratings		100 mc.

Mechanical

Base (medium 4-pin bayonet, ceramic) RMA type M8-078	
Basing	RMA type 2M
Maximum overall dimensions:	
Length	5.75 inches
Diameter	1.81 inches
Net weight	2.5 ounces
Shipping weight (average)	1.25 pounds

Audio Frequency Power Amplifier and Modulator Class B

	Typical Operation 2Tubes			Max. Rating	
D.C. plate voltage	1000	1500	2000	2000	volts
Max signal D.C. plate current, per tube*	—	—	—	150	ma.
Plate dissipation, per tube*				50	watts
D.C. grid voltage (approx.)	—8	—25	—40		volts
Peak A.F. grid input voltage	240	250	255		volts
Zero-signal D.C. plate current	67	45	34		ma.
Max.-signal D.C. plate current	210	200	167		ma.
Max.-signal driving power (approx.)	7	5	4		watts
Effective load, plate-to-plate	7900	16200	27500		ohms
Max-signal plate power output	140	200	235		watts

*Averaged over any sinusoidal audio frequency cycle.

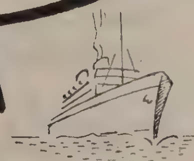
Radio Frequency Power Amplifier and Oscillator Class C Telegraphy*

(Key down conditions without modulation)

	Typical Operation—1 tube			Max. Rating	
D.C. Plate voltage	1000	1500	2000	2000	volts
D.C. plate current	125	125	125	150	ma.
D.C. grid current	40	40	45	50	ma.
D.C. grid voltage	—60	—120	—135		volts
Plate power output	87	141	200		watts
Plate input	125	188	250		watts
Plate dissipation	38	47	50	50	watts
Peak R.F. grid input voltage (approx.)	165	250	285		volts
Driving power (approx.)	7	9	13		watts

*The above figures show actual measured tube performance, and do not allow for variations in circuit losses.

FURTHER SHIPMENTS HAVE ARRIVED



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Hobbies Exhibition

A "must" for those with a minute or two to spare is the forthcoming Hobbies' Exhibition to be held in the D.I.C. Art Gallery from the 20th to 29th September, 1950.

The exhibition will feature displays by members of the Numismatic Society, Model Railways Club, Model Aeroplane Clubs, displays of carving, model ships, butterflies, pirate chests, working models of steam engines, photographic and art displays, postage stamps, glass blowing, and tropical and sub-tropical fish.

Displays are to be shown by the pupils of Thorndon School, Rongotai College and by the students of the Wellington Teachers Training College. An approach has been made to the Wellington Technical College to participate also.

The Hutt Valley Federation of Women's Institutes will have a display of the art and craft work of its members.

Negotiations are at present in progress to obtain and display the television set that was constructed by Auckland radio engineer enthusiasts. If it is at all possible, a working display of this set will be arranged.

The purpose of the exhibition is to foster hobbies and hobby clubs in Wellington and to raise funds for the United Nations Appeal for Children.

The Mayor, Sir William Appleton, will open the exhibition at 2.30 on Wednesday, September 20th, and the Minister of Internal Affairs, Mr. W. A. Bodkin, will also speak at the function.

The Wellington Junior Chamber of Commerce is organizing the exhibition and the convenor, Mr. J. B. Steel, requests hobbyists interested in placing their models and collections on display to contact the office of the Executive Secretary, Junior Chamber of Commerce, 2nd Floor, "Dominion" Building, Wellington.

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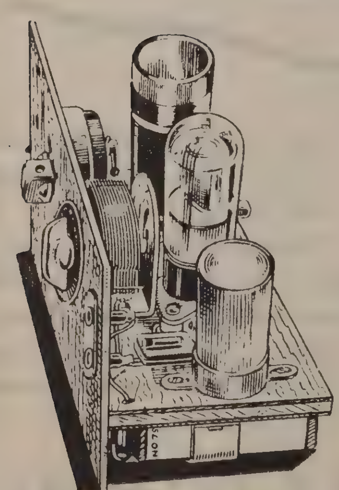

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The miniature set with power to pull in main New Zealand stations; plus Australian reception under favourable conditions.
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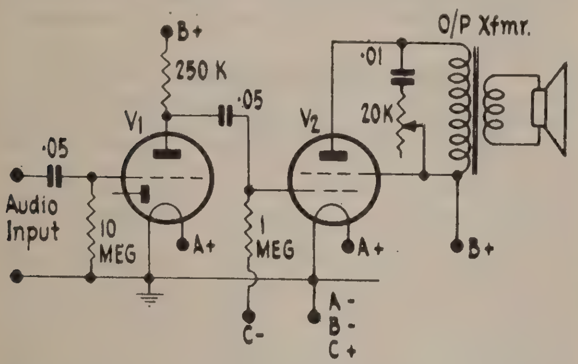
A PRACTICAL BEGINNERS' COURSE

Part 41

After a lapse of several months, we again take up the Practical Beginners' Course, this time with some more about audio amplifiers. First of all, we have a small battery-operated amplifier, suitable for adding to any of the crystal or one-valve sets we have already built. Such an amplifier is extremely handy for an experimenter to have round, since the amplifier sectoin of any set is much like the same section of most other sets, and serves the same purpose; thus, when it is desired to build a new circuit that is found, say in a new issue of our favourite radio paper, we need build only as far as the detector, and let our permanent amplifier do the rest. Contrary to the opinions of many, a small battery-operated ampli-



fier will give quite enough volume for all ordinary purposes, and as far as other people are concerned, sometimes more than enough. This little amplifier gives as much as the average portable receiver, so that it is quite able to fill a room with sound. If you are one of those who prefers to do his experimentation with battery valves, keeping away from power transformers, and power packs worked from the mains, then this amplifier will suit very well. It can be run successfully off even very small dry batteries, but if it is to be more or less permanent about the place, it is wise, if it can be afforded, to invest in some of the larger types. Even the very large heavy-duty types could be used, and would give very long service, even if used for several hours every night.

This amplifier gives us our first introduction, moreover, to what is called the resistance-coupled amplifier, which is the name given to V_1 in the diagram. It is given this name in order to distinguish it from other kinds of amplifier, one of which we have already met, namely the transformer-coupled amplifier. Now this kind of amplifier has a transformer feeding the signal voltage to the grid from the valve preceding it, and also has a transformer connected in its plate circuit, and through this second transformer it supplies signal voltage for the next valve, or to the loud-speaker.

The resistance-coupled amplifier, on the other hand, has a resistor in its plate circuit, and it is across this resistor that the output voltage of the valve is developed. Now, in order to connect the output voltage to the grid of the next valve, we must in some way connect the grid of the second tube to the plate of the first. Unfortunately, we cannot do this, just as we have said it, because if we did, the large positive voltage at the plate of the first valve would be put on the grid of the second thus destroying the small negative grid voltage that every amplifier valve must have if it is to work properly. Actually, there are some special circuits known as *direct-coupled circuits* in which this is done, but in which special dodges are resorted to in order to see that the grid of the second valve is *not* raised to a positive voltage with respect to its filament or cathode. But we are not concerned with these circuits here. Instead, we must find some other way of connecting the plate to the grid of the next valve without destroying its grid bias. This diagram illustrates how we go about this. We connect the two together *through a condenser* which, as we already know, has the faculty of passing alternating voltages through it, but not direct ones. Then, so that we can fix the grid of the second valve at the right negative bias voltage, we insert a large resistor between the grid and the grid bias battery. The condenser which goes between the plate and grid of the valves is called the *coupling condenser* because it couples the valves together, and the 1 meg. resistor in the grid of the second valve is called the grid leak, just as in a detector valve. It is important to know, too, just why both this resistor, and the 250k. resistor in the plate circuit of V_1 must both be there for the arrangement to work. The first one is essential because without it, V_1 would not be able to develop any signal in its plate circuit. Let us imagine what woulid happen if we omitted this resistor, and instead took the plate of V_1 straight to B positive. The signal on the grid would vary the plate current of V_1 all right, but we would find no voltage at its plate except the B battery voltage. What we want, to make an audio signal, is the *variation* of plate voltage, and it is this variation that the condenser transfers to the grid of V_2. If we put a small resistor in the lead to the plate of V_1, the plate current would cause a voltage drop through it, so that in the absence of a signal on the grid, the only effect would be that slightly less than the B battery voltage would be found at the plate of V_1, Now, when a signal is applied to the grid, the negative half-cycle causes the plate current to decrease. Thus, the plate *voltage* would increase during this half-cycle. During the positive half-cycle, exactly the opposite would occur, and the plate current increase would be accompanied by a *fall* in voltage at the plate. Now within fairly wide limits, the larger we make the resistor in the plate circuit, the larger will be the voltage variations at the plate of the valve. In other words, the larger the plate resistor, the greater the amplification. Unfortunately, we cannot take this process too far, because if we do, the plate current decreases too much, and this effect works against the fact of the larger plate resistor, and the amplification, after a certain value has been reached, no longer increases much. In fact, for every particular type of valve, there is a best value for the plate resistor. On the other side of the coupling condenser, we try and make the grid leak as large as we can, because the bigger it is, the less it reduces the voltage given out by the first valve. Obviously, if we make the grid leak small or short-circuit it altogether, we will have no signal voltage left. We can look upon the valve's plate circuit as a battery, capable of giving a certain voltage at its terminals. If these are short-circuited, however, the voltage is nil. Another way of looking at it is that if the grid leak were short-circuited, the coupling condenser would be merely a bypass condenser, taking the signal voltage straight to earth. The other solution of what to do with

the grid of V_2, namely to connect it to the coupling condenser, and nothing else, will not work either, because we cannot then determine the voltage of the grid, and can no longer ensure that this will be right for the valve. Thus, we compromise somewhere in between, and put in a high resistor. This is so high that it has practically no effect on the signal voltage from V_1, but at the same time, connecting its lower end to the bias battery (C—) allows us to control the grid voltage of V_2.

Now with all this talk of bias voltages, someone will be bound to ask "where is the bias in this circuit, for V_1?" And this will be a very proper question to ask. According to the circuit, no bias battery is used for V_1, and the grid leak is taken straight to earth, so that by the look of things, there is no bias at all on the valve. Fortunately, this is not quite so, and this is an excellent case of things not always being what they seem.

In all valves, when the grid is connected to the cathode, as here, without any battery in the circuit, a very minute amount of grid current flows. This grid current is due to a phenomenon called *contact potential* which we cannot discuss here. The thing we are interested in at the moment is that such a grid current flows. Now it is usually only a few micro-amperes, or millionths of an ampere, so that when the grid resistor is small, it does not result in any appreciable voltage being developed across the grid resistor. But, if we purposely make the grid resistor very large indeed, say 10 megs., as here, these few microamperes are able to build up an appreciable voltage. It is found that with some valves, the grid current is such that with about 10 megohms of grid leak, about 1.5 to 2 volts is built up across the grid leak. This voltage is always of such polarity as to make the grid negative, so here we have a cheap way of getting grid bias for certain valves. This is the scheme used for V_1 in this circuit.

VALVES FOR THE AMPLIFIER

Perhaps the best valves to use for this circuit are the 1H5 for V_1, and the 1C5 for V_2. For these, a B battery of 90 volts will be required, and an A battery of 1.4 volts. The C battery, for biasing V_2 should be a 9-volt bias battery, only 7½ of which is used. The 1C5 will give just over 250 milliwatts, or ¼ watt output, which is a good deal more than modern portable sets will give. The correct transformer to use is one which will match the speaker to a load of 8000 ohms. This may be difficult to get, since 8000 ohms is not a very much-used figure for this sort of thing, but failing that, a 7000-ohm transformer will do quite well. If you have a fairly large speaker, do not be afraid to use it with this little amplifier. In fact, the results will often be rather better with a bigger speaker than with a small one, since the very small speakers usually used with battery valves are not as a rule as sensitive as, say the average 8 in. speaker. If you are buying a speaker for the purpose, we would recommend an 8 in. speaker with a 7000-ohm transformer, since this will come in handy later on when you want to build your first full-sized A.C.-operated set. It will also give excellent results with the little amplifier.

(To be Continued.)

ROLA "ANISOTROPIC" SPEAKERS ARE GUARANTEED FOR 12 MONTHS FROM DATE OF MANUFACTURE.

QUESTIONS AND ANSWERS

COSSOR 23D CATHODE RAY TUBES

"A.V.," Upper Hutt, who read our reply last month to "R.W.G." of Christchurch, on the subject of cathode ray tubes for our recent circuit, has very kindly sent us in some details of the Cossor 23D, mentioned in "R.W.G.'s" letter. These are copied from the Cossor leaflet on these tubes, and from a perusal of the data, they appear to be identical with the E4102 mentioned in our article. Deflection sensitivity is the same, the base connections are the same, and the maximum permissible anode voltage is 2000 volts. We are thus in a position to advise readers that those who have Cossor 23D tubes can use them in our circuit without any alterations whatever. We would like to thank "A.V." very much for his letter and the detailed information contained therein, and to say that any person who would like to have the complete data as sent by him may obtain it by writing to us and requesting it.

HUM IN AN AUDIO AMPLIFIER

"V.R.S.," Levin, has an amplifier with exceedingly high gain, and which is used with a velocity microphone. It suffers from hum in the output, but when the cathode of the 6N7 first stage is directly earthed, the hum disappears. Our correspondent wishes to know what we would recommend as a method of permanently curing this hum.

Now when a high-gain amplifier suffers from hum in this way, there are a number of possible reasons, but "V.R.S." has given us the clue to the cause of the trouble in his case. The amplifier line-up is as follows: 6N7, used as an electronic mixer stage, two cascaded 6SJ7s as voltage amplifiers, 6N7 phase inverter, and 6F6s in the output stage. This is a formidable array of gain, even if the second 6SJ7 is triode-connected, which our correspondent does not state, and when collected together on one chassis, it might be expected that hum trouble would be encountered. It speaks volumes for our correspondent's construction that with this line-up the hum disappears when the first cathode is earthed. This fact proves that the hum is not due to poor wiring of the input circuit, which is a very prolific source of difficulty. The hum that can be heard must be due to the A.C. potential difference between heater and cathode, combined with the D.C. potential difference brought about by the use of cathode bias. The reason for the hum is therefore *either* emission of electrons by the heater to the cathode, *or* heater-cathode leakage. Whichever of these two is the real cause, it can probably be cured by returning the heater to a higher D.C. voltage than that of the cathode, or to a much lower D.C. voltage. The former is quite easy to do as long as there is a separate heater winding for the first tube in the amplifier, because all that needs to be done then is to return the heater, centre-tapped by means of two equal resistors, or preferably by a low-resistance potentiometer, to some positive point on a voltage divider connected to the positive H.T. supply. Ten volts or so is often sufficient. Returning the heater to a negative potential is just as easy if a source of negative potential exists in the amplifier, but if it does not, it is rather more difficult, since a special source of negative voltage will have to be provided. However, in this case, since it is known that earthing the cathode of the first valve cures the hum, perhaps the best method is the "brute force" one—namely, earthing the cathode, and providing a separate source of negative bias for the tube. This could be a small battery, or could be a midget bias supply, obtained by

rectifying the heater voltage with a small diode, such as a 6H6, smoothing, and applying to the grid leaks of the 6N7.

OUTPUT ARRANGEMENTS FOR A SIGNAL GENERATOR

"G.R.K.," Auckland, writes us that he is building the "Radel Service Oscillator," as described in the July 1947 issue of this journal. His trouble is that he is not very taken with the simple attenuator system shown in that circuit, and would prefer to use a proper attenuator which will give him much better attenuation.

Unfortunately, the problem is not quite so easy as our correspondent would like it to be, for if it is desired to build a signal generator with very good attenuation and small leakage, it is a matter that must be considered right from the start, particularly when the chassis, case, and shielding arrangements are being designed. Unless this is done, and successfully, too, so that the leakage is negligible, there is no point in adding a complex or expensive attenuator circuit, since the attenuator has unfortunately no bearing on what comes out due to leakage. Under these circumstances, the attenuator is only misleading, giving no real indication of the size of the output signal. Since the signal generator we are discussing was not designed for very low leakage, we must regretfully inform "G.R.K." that we do not think the addition of a good attenuator to the circuit to be worth while.

His second query refers to the addition of a percentage modulation meter circuit to the original.. Here again, this is a feature only of the most expensive instruments, which the service oscillator referred to makes no attempt to emulate. Our correspondent's requirements are really for a standard signal generator, which is a very expensive piece of equipment, and which would be expected to have these features. We must say again, that it would not be worth the trouble to put a percentage modulation meter on an oscillator like this one, because the audio waveform while satisfactory for alignment purposes, is not pure enough by a long way, for the percentage modulation to be calculated. It would be possible to incorporate an audio volume indicator, such as was described in a recent issue of this journal, but for the reason given, it would not be possible to calibrate this as percentage modulation.

MODIFICATIONS TO THE "80–40–20 BANDSPREAD TUNER"

"A.F.E.," from Melbourne, Australia, writes with an interesting scheme for modifying the above bandspread tuner. His idea is to use a 6J6 and 6J4 in the same sort of oscillator-mixer circuit as we used in the "Junior Communications Receiver" some time ago. This would replace the ECH21 oscillator-mixer in the 80-metre section of the tuner. His next idea is to omit the R.F. stage, so as to have only two circuits to track instead of three. The same scheme for getting the bandspread on 40 and 20 would be used, so that the modified tuner would have only the two oscillator-mixers, and no R.F. stage, the latter now being unnecessary from the point of view of signal-to-noise ratio. "A.F.E.'s" questions are: (1) Whether it would not be a good idea to use a Clapp oscillator circuit in the 80m. oscillator section so as to gain added oscillator stability; and (2) whether there would be any difficulty in tracking the mixer and oscillator tuned circuits.

While the idea of using a Clapp oscillator circuit in a receiver is an excellent one, we do not think that the added stability would really be worth the trouble. We have conducted exhaustive tests of the stability of the oscillators in this tuner, with a view to finding out whether they are stable enough for very high selectivity to be placed after it. We can say that *each* oscillator itself is quite stable enough for even the most stringent requirements, and that we do not think that extra stability is necessary. After the initial warm-up period, frequency drifts were no more than 50 c/sec. above and below the mean frequency when a regulated power supply was used. Also, on the 40 and 20 bands, where double-conversion takes place, and thus two oscillators are at work at once, the drifts tend to cancel out, because one oscillator is on the high side of its signal frequency while the other is on the low side. Drifts in the same direction therefore produce opposite shifts in the output frequency and the drifts therefore tend to cancel out. This, of course, applies only to the warm-up period, while the oscillators are reaching their final working temperature, and not to the minute random drifts which take place after this. However, we have no hesitation in recommending the tuner just as it is, with the rider that anyone who wishes to use Clapp oscillator circuits for one or all of them can certainly do no harm. Only one difficulty would arise, however, and that is that even over a narrow band like the 80-metre band, the output of a Clapp oscillator varies considerably from one end of the band to the other. It might thus be difficult to ensure that the oscillator-mixer was operating at best efficiency at all frequencies in the band.

As for tracking of the circuits, we would like to emphasize that in the bandspread tuner this is no difficulty at all, even with the R.F. stage. The reason is, of course, that the band is so narrow that even if no padding were done the tracking error would be exceedingly slight. But here, the series bandspread condensers allow the oscillator circuit to be padded simply by setting its series condenser at slightly smaller capacity than the signal circuit ones. With this tuner, there will be no difficulty at all in making the sensitivity absolutely even over the band.

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Pulse Modulation

(Continued from Page 12.)

tion variations in the pulse amplitudes can be removed by limiting or clipping circuits such as are used in FM practice, without impairing the signal modulation.

Another advantage incidental to the use of pulse modulation lies in the fact that it enables the use of vacuum tubes at frequencies considerably higher than the c.w. limit for the same type. The very high pulse voltages applied reduce the freqeuncy limiting effects of electron transit time. In applications where the duty cycle is sufficiently low, the upper frequency limit for a given tube type may be more than doubled.

Trade Winds

(Continued from Page 16.)

PUBLICATIONS RECEIVED

From National Elec. & Engineering Co., Ltd., British Insulators & Cables, Catalogues on Radio Frequency Cables, Solders and Flexes, Power Capacitors.

* * *

W. G. Leatham Ltd. Fielden sales folder on Proximity Meter type P.M.I.

* * *

Philips Electrical Industries of N.Z. Ltd. Valve substitution data book for U.S.A. valves.

* * *

Amalgamated Wireless Valve Co. Chart on power valves' characteristics and basing diagrams, "Radiotronics" No. 143, June, 1950.

* * *

Industrial Electronics Ltd. Descriptive leaflet, Collins Type 51J-1 Communications Receiver.

* * *

Another visitor to Australia is Ron Greenwood of National Carbon.

* * *

Grover Electrical Co. Ltd. desire to call attention to and apologize for an error in a recent advertisement in that the price of Grover Lightning Arrestors was shown as 2/-. The correct price is 2/6 as appears in an advertisement of this issue.

Communications Receiver

(Continued from Page 8.)

the full circuit of the receiver, and will describe the circuit in detail. For the benefit of those who may already be thinking of building the set, we present here working drawings for the chassis and panel of the I.F. unit. It is strongly recommended that in the interests of stable and continuing performance, the chassis should be made of heavy-gauge steel, and that the panel should be even heavier, of steel or aluminium at least $\frac{1}{8}$ in. thick. We cannot emphasize too greatly the fact that the excellent performance of our own prototype is due as much to solidity of mechanical design as to good circuit design. Such things as the special 100 kc/sec. amplifier cannot be expected to perform at all if built on a flimsy base, and if there is the slightest "whip" in the chassis, the builder will have reason to be sorry later on. It is much better to err on the side of great weight than that of insufficient rigidity. After all, we are not building a personal portable, and it might be as well to make it so heavy that your friends cannot easily carry it off after they have heard it perform!

(To be continued.)

Electronics in Civil Aviation

(Continued from Page 34.)

scoped in air transport into ten years. A new and unexplored field for the application of telecommunications is an absolutely essential part of this rapid progress and the next decade will produce the most intriguing developments.

Book Reviews

(Continued from Page 42.)

To return to the book under review however, this appears to cover the field very completely, though by its nature the treatment of many of the important topics must of necessity be brief. The material is very up-to-date, considering the rapidity with which technical developments in the field take place and become a part of standard practice. For those requiring a ready reference to the technical side of television, this book should be exceedingly valuable, especially where the answers required are compact, and it should save a great deal of delving through standard works. However, it would have been even more useful had a comprehensive bibliography been included, so that those requiring more detailed information can go to authoritative sources for it.

Index to Advertising

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